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New Scientist

THE FIRST ARTISTS

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Instant Expert

Artificial intelligence

Following the release of ChatGPT, there has been an explosion of interest in generative AIs that create text or images. But how do these systems work? And what are the ethical, social and political challenges they raise? Join our expert speakers in London on 25 November to hear about advances in natural language processing, computer vision and AIs for the creative arts.

newscientist.com/events

Tour

Tasmania's flora, fauna and geology

Australian island Tasmania boasts golden beaches, misty mountaintops and lonely patches of wilderness. Join biologist and conservationist Martin Cohen in seeking out Tasmanian devils, platypuses and fairy penguins. Wander among ancient geology and discover the island's Indigenous culture. This 12-day tour begins on 20 February 2024 and tickets cost £4595.

newscientist.com/tours

Podcast

Weekly

This week, the team reveals how a centuries-old idea for harvesting energy from the ocean is being realised and explains why crabs left the ocean 17 times in their evolutionary history. There is an exciting story about how spinal cord stimulation is helping a man with severe Parkinson's disease walk more easily. Plus, rats that make happy squeaks when they hang out with their friends.

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Fairy penguin The smallest of all the penguins is found in Tasmania

DAVID STOCK

Cyborg pianist MiMU gloves use sensors in the fingertips and wrist

Video

Techno meets piano

Pianist and technologist Zubin Kanga's latest work, which recently premiered at Kings Place, London, fuses motion detection gloves, brainwave sensors and artificial intelligence. Kanga hopes to create a new repertoire for the classical piano that brings it into the 21st century. "We now have this capability of becoming these cyborg musicians," he says.

youtube.com/newscientist

Book club

1984 retelling

The latest pick for *New Scientist*'s book club is Sandra Newman's harrowing, fascinating take on George Orwell's classic dystopia *Nineteen Eighty-Four*. Her novel, *Julia*, is told from the perspective of the woman who is the lover of the protagonist Winston Smith. Come and read along with us and enjoy lots of extras.

newscientist.com/bookclub

Podcast

> "Researchers developed little bitty microphones that they could place inside a rat's nose"

Essential guide

Our lives are often governed by the familiar ticking of the clock, but where does that ticking come from? This *New Scientist Essential Guide* explores why time is the fundamental facet of our existence. Available to download in the *New Scientist* app or to purchase in print from our shop.

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Of art and artefacts

To make sense of ancient objects, archaeologists must temper imagination with science

IN HIS poem *The Conundrum of the Workshops,* Rudyard Kipling imagined an early human pausing to admire a drawing he had scratched in the dirt, only to hear a voice whispering: "It's pretty, but is it Art?"

Archaeologists know a bit about scratching in the dirt, and when their excavations reveal a beautiful ancient object, they find themselves asking the very same question. They are motivated by a desire to step inside the minds of our prehistoric ancestors. In many cases, they want to understand if and when ancient hominins began to create art, as we explore on page 32.

Consider the Neanderthals. For decades, we thought of them as brutish, subhuman creatures lacking in creativity. Recent archaeological finds, including a painted fossil shell that was carried 100 kilometres by a Neanderthal, suggest otherwise. What's more, a growing collection of evidence suggests that earlier hominins may have possessed an artistic sensibility, potentially pushing back the origins of art by millions of years.

> **"Herein lies the joy: we use our imaginations to figure out how our ancestors saw the world"**

Only potentially, though, because ancient artefacts often throw up "interpretive tensions". To understand what they meant to their creators, archaeologists have to make inferences. There is a danger of taking that too far, of course, and any claims that an artefact was intended as a work of art should be treated with caution, considering all alternative possibilities. But herein lies the joy of all this: we have to use our imaginations to figure out how our ancestors saw the world.

That doesn't preclude a scientific approach. The West Tofts hand axe is a good example. A 300,000-to-500,000-year-old tool created from a piece of flint containing a fossil shell, it looks like a work of art. By analysing exactly how the tool had been made and used, however, archaeologists showed that the fossil's prominent position is a mere coincidence.

There can be no doubt that art has a long prehistory. But to truly unravel its origins, and to understand how ancient hominins thought, requires a meeting of rigorous science and imagination. ▮

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News

Family boost
Seeing loved ones cuts risk of early death **p8**

Turtle sex
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Surgical success
First transplant of a human eyeball goes without a hitch **p10**

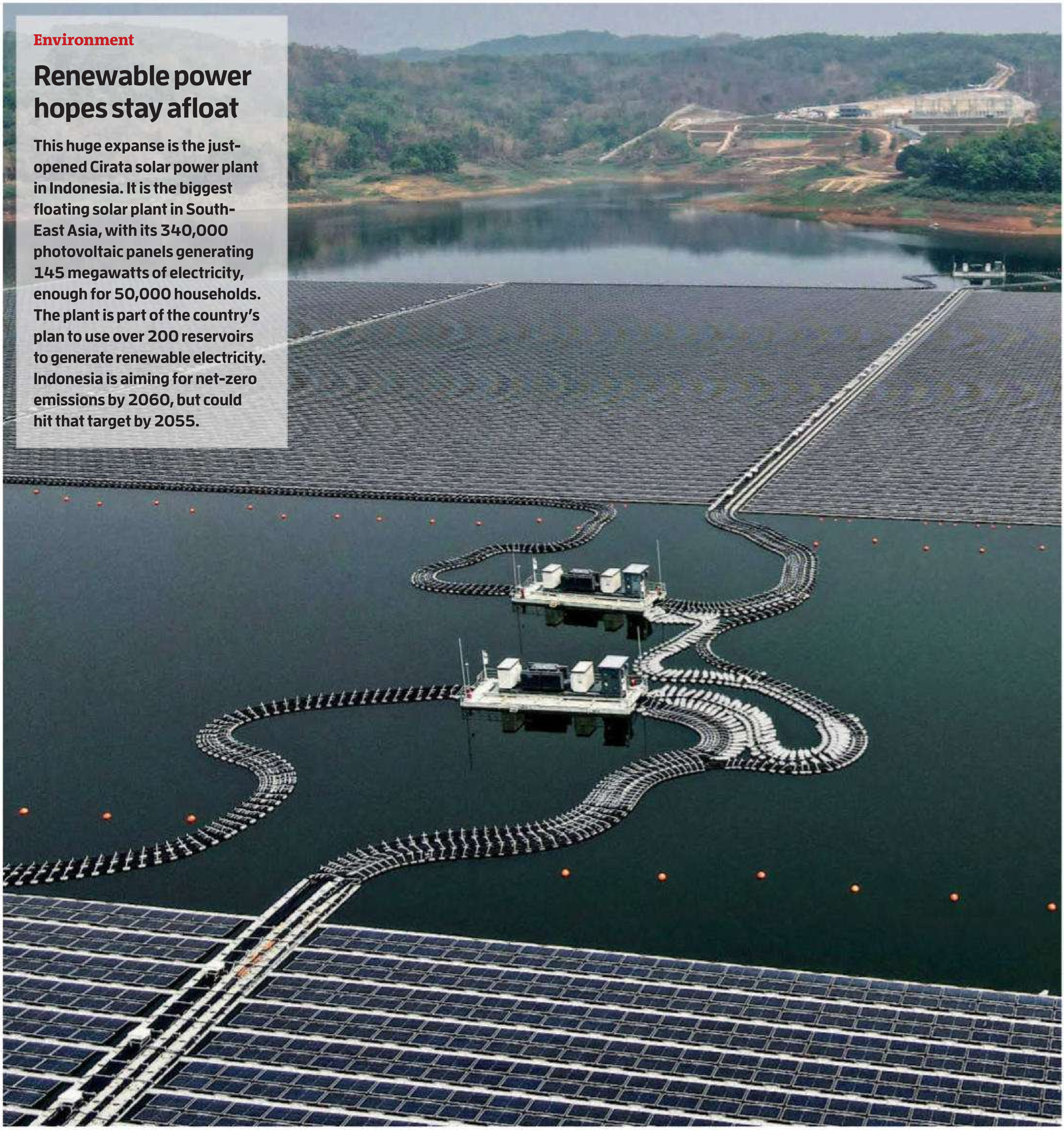
Distant black hole
Supermassive object spotted further away than ever before **p14**

Temperature high
The past 12 months were the hottest ever on record **p18**

Environment

Renewable power hopes stay afloat

This huge expanse is the just-opened Cirata solar power plant in Indonesia. It is the biggest floating solar plant in South-East Asia, with its 340,000 photovoltaic panels generating 145 megawatts of electricity, enough for 50,000 households. The plant is part of the country's plan to use over 200 reservoirs to generate renewable electricity. Indonesia is aiming for net-zero emissions by 2060, but could hit that target by 2055.



BAY ISMOYO/AFP VIA GETTY IMAGES

Analysis **Weight-loss drugs**

Wegovy averts heart attacks – will this widen use?

A trial has found that the weight-loss injection Wegovy can also ward off heart problems. This could make it more accessible, says **Clare Wilson**

WEGOVY, the weight-loss injection made up of the drug semaglutide, can cut people's chance of having a heart attack or stroke, a trial has found.

This might seem like just the latest in a long line of positive studies for the medicine, but doctors who work in the field say this is a key result. In time, it could become as normalised to have weight-loss injections for your health as it is to take cholesterol-lowering statins.

Semaglutide is a once-weekly injection that mimics the actions of a hormone called GLP-1, normally released after eating. It makes people feel fuller, suppresses appetite and triggers the release of the hormone insulin, which is involved in controlling blood sugar.

The GLP-1 mimics, of which there are others, were first used for people with type 2 diabetes, but have more recently been used for weight loss, with semaglutide leading to an unprecedented 15 per cent loss in body weight on average. When it was launched in the US in 2021, under the brand name Wegovy, it triggered a surge of public and media interest.

There has been much moralising over whether it is right for people to use injections to control their weight. Some say we should instead eat more healthily and do more exercise. But certain doctors who specialise in treating obesity and diabetes have been enthusiastic about the potential of this class of medicines.

Until now, there have been two things stopping everyone who might benefit from getting access to the injections. One is their cost. In the US, the official manufacturer's price of Wegovy is $1349 a month, and while health providers typically negotiate discounts, many insurance schemes don't cover it or require high contributions from the people taking it.

Insurers will probably widen access once they see evidence that the drug not only causes weight loss, but also prevents medical conditions – and heart disease is one of the leading causes of illness and death. The latest study showed that people having semaglutide injections at the Wegovy dose for up to five years had a 20 per cent lower rate of heart attacks, strokes or deaths from these conditions compared with those in a placebo group (*NEJM*, doi.org/gs4ph8). To put this into context, it is a similar degree of cardiovascular benefit as is seen when taking statins.

2021

Wegovy first launched in the US in this year

$1349

Official monthly cost of Wegovy in the US

20%

How much Wegovy cuts heart attacks and strokes

"The importance of [this] trial cannot be emphasised enough," says Louis Aronne at Weill Cornell Medicine in New York, who has been involved in other semaglutide research. "For the first time, we have proof that using a medicine that induces weight loss in people without diabetes reduces the risk of death, heart attack and stroke in people who are otherwise being managed for hypertension and [high cholesterol]."

A second issue preventing take-up is that Novo Nordisk, the Danish firm behind semaglutide, can't make it fast enough to cope with demand. It has repeatedly delayed launch plans for Wegovy outside the US, although the drug is now available in Germany and England.

That problem may be helped by the US approval this week of a further weight-loss injection, called tirzepatide (brand name Zepbound), which mimics the actions of GLP-1, as well as another hormone called GIP. While tirzepatide and Wegovy haven't yet been compared in a head-to-head study, a trial of tirzepatide against a placebo suggests it is even more potent, leading to an almost 21 per cent weight loss on average.

Once Zepbound is launched in the US, increased supplies of this drug class may ease shortages. What's more, the price for Zepbound is set to be about $1060, which may lead Novo Nordisk to lower the cost of Wegovy. This suggests that more people who want weight-loss injections will soon be able to get their hands on them.

Looking further ahead, when GLP-1 mimics become available in cheaper generic versions, doctors may encourage people to use them to control their weight with the enthusiasm they often have for persuading people to take statins.

The latest trial results may bring home like never before the fact that treating obesity isn't just a cosmetic issue, but a medical one. ▮

Health

Frequently seeing loved ones may cut risk of early death

Grace Wade

SPENDING time with friends and family may reduce your chances of an early death, while a lack of such visits can raise the risk.

Hamish Foster at the University of Glasgow, UK, and his colleagues have collected data from more than 450,000 people aged between 38 and 73 living in the UK.

MOMO PRODUCTIONS/GETTY IMAGES

Seeing family members seems to keep us alive for longer

Between 2006 and 2010, all the participants completed a physical health assessment and questionnaire on social connections. The questionnaire asked how often they felt lonely, could confide in someone close, had friends or family visit and participated in weekly group activities. It also asked if they lived alone.

The researchers then tracked the participants to find out how many had died by 2021.

After adjusting for factors including age, sex, physical activity, socioeconomic status and chronic health conditions, the researchers found that, on average, people whose friends or family never visited had a 39 per cent greater risk of dying during the study period than those whose loved ones visited daily. Even those who didn't live alone had a 25 per cent greater risk of death in this time if they had no visits. Participating in weekly group activities didn't alter the effects (*BMC Medicine*, doi.org/k426).

The team also found that the risk of dying during the study period was about the same for those whose loved ones visited monthly, weekly or daily. "Monthly visits seems to be enough," says Foster. ▮

Technology

DeepMind AI predicts the weather

Spotting patterns in data lets Google DeepMind beat the best weather forecasts – sort of

Matthew Sparkes

ARTIFICIAL intelligence can predict the weather 10 days ahead more accurately than current state-of-the-art simulations, says AI firm Google DeepMind. However, ditching current forecasting methods and just relying on AI spotting patterns in data could raise serious issues.

Existing weather forecasts are based on mathematical models, which use physics and supercomputers to deterministically predict what will happen. These models have become more accurate by adding finer detail, which, in turn, requires ever more powerful computers and higher energy demands.

Rémi Lam at Google DeepMind and his colleagues have taken a different approach. Their GraphCast AI model is trained on four decades of weather data from satellites, radar and ground measurements, identifying patterns that not even Google DeepMind understands. “Like many machine-learning AI models, it’s not very easy to interpret how the model works,” says Lam.

To make a forecast, it uses real meteorological readings, taken from more than a million points around the planet at two given moments in time 6 hours apart, and predicts the weather 6 hours ahead. Those predictions can then be used as the inputs for another round, forecasting a further 6 hours into the future.

Researchers at Google DeepMind ran this process with data from the European Centre for Medium-Range Weather Forecasts (ECMWF) to create a 10-day forecast. They say it beat the centre’s “gold-standard” high-resolution forecast (HRES) by giving more accurate predictions on more than 90 per cent of tested data points. At some altitudes, this accuracy rose as high as 99.7 per cent (*Science*, doi.org/k433).

Matthew Chantry at the ECMWF, who worked with Google DeepMind, says his organisation had previously seen AI as a tool to supplement existing models, but it has now come to be regarded as something that could provide forecasts on its own.

> **“Like many machine-learning AI models, it’s not very easy to interpret how the model works”**

“We at the ECMWF view this as a hugely exciting technology to lower the energy costs of making forecasts, but also potentially improve them,” he says. Google DeepMind says that making 10-day forecasts with GraphCast takes less than a minute on a high-end PC, while HRES can take hours of supercomputer time.

But meteorologist Ian Renfrew at the University of East Anglia, UK, says GraphCast can’t just gather its own data to kick off a forecast. Like the ECMWF’s own tools, it needs starting states placed into the simulation after thorough checks against physics and chemistry calculations. This is typically half to two-thirds of the computing time in forecasting systems, says Renfrew.

He also has concerns about ditching deterministic models and relying on AI output alone. “If you set out an order to evacuate 30 miles of coastline in Florida, and then nothing happens, then you’ve blown decades of trust that has been built up,” he says. “The advantage of a deterministic model is you can interrogate it and if you do get bad forecasts, you can interrogate why they’re bad forecasts and try to target those aspects for improvement.” ▮

Marine biology

Metal pollution may be skewing the sex ratio of sea turtles

NORBERT PROBST/ALAMY

A green sea turtle resting on a sandy seabed at the Great Barrier Reef off Australia

CHEMICAL pollution could be making more sea turtle eggs hatch as females, putting the animals at risk of extinction.

Sea turtles are one of many reptiles whose sex depends on temperature. In warmer nests, offspring are more likely to hatch from eggs as females, while cooler nests favour male turtles. As global temperatures continue to rise, more and more sea turtle populations are becoming overwhelmingly female, a trend that could lead to their disappearance.

Now, Arthur Barraza at Griffith University in Australia and his colleagues have found that pollution on beaches may also be driving the sex bias in green sea turtles (*Chelonia mydas*).

The researchers collected 17 newly laid clutches of eggs on Heron Island in the Great Barrier Reef, then reburied them near sensors that monitored the sand’s temperature. After the eggs hatched, the researchers euthanised the turtles from 16 of the clutches. They found that 11 clutches had more females than predicted from temperature alone, three had more males than expected and two matched the expected sex ratio.

The hatchlings in the clutches with more females than predicted had higher levels of cobalt, lead and antimony in their bodies, while those with more males had lower levels of the heavy metals (*Frontiers in Marine Science*, doi.org/k4zt).

Most of these metals are waste from industrial processes, says Barraza. The findings show correlation and aren’t proof that metal pollution is altering hatchling sex. But the metals can bind to oestrogen receptors, which may trigger female development, says Barraza. “Human pollution affects turtles and wildlife in ways that maybe people do not expect.” ▮

Chen Ly

Medicine

Eyeball transplant success

It was thought impossible, but surgeons have performed the first human eyeball transplant

Grace Wade

IN A world first, surgeons have performed an eyeball transplant. It is uncertain if the recipient will be able to see using his new eye, but the procedure remains a significant step towards one day restoring vision in people who have had severe eye injuries.

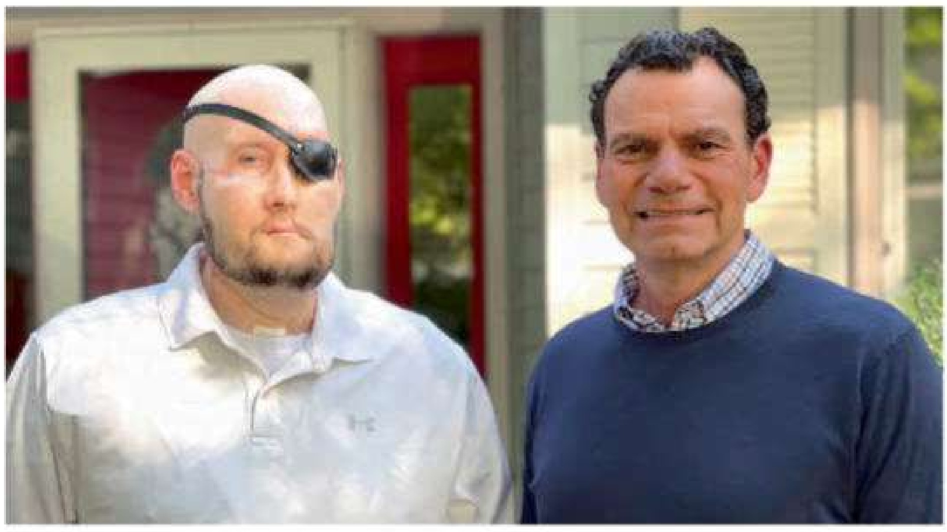
On 27 May, Eduardo Rodriguez at NYU Langone Health in New York and a team of more than 140 others performed the eye transplant alongside a partial face transplant on Aaron James, a power-line worker from Arkansas. To date, fewer than 50 facial transplants have been performed and none included an eye. Whole-eye transplants have been deemed nearly impossible due to the organ's complexity.

James thanked the donor and the donor's family at a press conference on 9 November, saying: "Before the transplant, emotionally, I was a little down. My confidence level was a little low. But since the transplant, I tell people I can't walk past the mirror without looking at it. It has made me stand up taller."

James was injured in June 2021 after his face touched a live wire, sending 7200 volts through his body. He lost most of the left side of his face, including his left eye, as well as much of his left arm.

Rodriguez and his team transferred the nose, lips and bone segments underlying the left cheek and chin of a deceased donor to James. They also transferred the entire left eye, including the eyelids, eyebrows and eye socket. The entire procedure lasted about 21 hours.

Aaron James (left) with plastic surgeon Eduardo Rodriguez



RUSS GELTMAN/NYU LANGONE HEALTH

Doctors have never successfully reconnected a severed optic nerve. In an attempt to do so, the team preserved as much of the optic nerve's length as possible, with the goal of maximising the chances of the nerve fibres regenerating and establishing a connection with James's brain.

The team also took stem cells – which can develop into different types of specialist cells – from the donor's bone marrow, and injected them where the donor optic nerve and James's optic nerve met, to further stimulate nerve growth.

More than five months after the surgical procedure, the eyeball seems healthy. It has sufficient blood flow and internal fluid pressure and can produce tears. Some of the nerve cells critical for sight are also alive, although James is unable to see using the eye and might never do so, says Rodriguez.

"That's an achievement, just keeping the globe viable, alive and healthy," says Damon Cooney at Johns Hopkins University in Maryland, who wasn't involved in the surgery. "[But] we need to be careful about raising people's expectation or hopes in excess of what's technically feasible."

"The fact the individual survived the operation, the fact we've not had any complications whatsoever – and there could have been many – is a success," says Rodriguez.

James can also eat and breathe on his own thanks to the surgery. "The fact that we can give this person another chance at a normal life with the possibility of some form of sight is wonderful," says Rodriguez.

Chemistry

Robot works out how to make oxygen from Mars minerals

A CHEMISTRY robot has developed an oxygen-producing catalyst from minerals found in Martian meteorites. The procedure could one day be used to provide oxygen for astronauts on Mars.

Sending supplies to a future Martian colony by spacecraft would be expensive, which makes producing materials with Mars's natural resources an appealing option. But the Red Planet doesn't have the same wealth of elements as Earth does.

To get round this, Yi Luo at the University of Science and Technology of China in Hefei and his colleagues turned to their fully automated robot. The machine used a laser to analyse the chemical make-up of five Martian meteorites and found six elements in significant quantities: iron, nickel, calcium, magnesium, aluminium and manganese.

When it comes to catalysts, "on Earth, we don't use these six elements because we have more choice", says Luo.

There are more than 3.7 million different combinations of the Martian elements, so it would take more than 2000 years to test which mix was best as a catalyst if it took 5 hours to test each one, says Luo.

Rather than checking every combination, the robot used artificial intelligence to predict which mix would make the best catalyst for generating oxygen. It then produced and tested more than 200 catalysts, using a briny solution and carbon dioxide as the raw materials.

The robot settled on a catalyst that is comparable to the best available catalysts on Earth from 10 years ago, says Luo. The catalyst can work at -37°C (-35°F), similar to temperatures on Mars, and for more than six days continuously (*Nature Synthesis*, doi.org/k42d).

It still might be easier to design materials on Earth and send them to Mars, but robot chemists could help with exploring further out in the solar system, says Ross King at the University of Cambridge.

Alex Wilkins

"Robot chemists could help with exploring further out in the solar system than Mars"

Technology

Walkie-talkies could work long-distance underwater

Alex Wilkins

DIVERS could soon communicate underwater over large distances by sending radio messages along the water's surface, getting around the fact that radio frequencies can't travel far through water.

Alternative communication systems that use sound, such as sonar, can transmit across long distances underwater, but these can't carry large amounts of information, are relatively slow and can disturb marine wildlife.

Now, Igor Smolyaninov, a co-founder of communication technology firm Saltenna in California, and his colleagues have found a way to communicate using radio waves by exploiting how electromagnetic radiation travels along the water's surface. "Two divers, for instance, completely submerged in the water, all of a sudden can use their walkie-talkies," says Smolyaninov.

This makes sense according to the principle of least time, proposed by Pierre de Fermat in the 17th century, he says. This predicts that light, a form of electromagnetic radiation, always takes the quickest possible path to its destination.

Smolyaninov and his colleagues have designed an antenna that can direct and receive radio waves that have passed vertically through a small amount of water and then send them across the surface.

You can send information, such as live, high-definition video, by this method, says Smolyaninov.

In tests in a freshwater lake, divers using the antennas could communicate over distances many times further than would be possible if sending the signal directly through the water. At 8 metres below the surface, it works at about 10 metres apart, but the closer to the surface you are, the greater the distance it will work across, up to hundreds of metres (*Scientific Reports*, doi.org/k4x6). ▮

Analysis **Climate change**

Will global warming continue after we reach net zero?

Taking longer to cut emissions could see the planet continue to warm for some time afterwards, finds **Michael Le Page**

LUKAS SCHULZE/GETTY IMAGES

Greenhouse gases in the atmosphere drive global warming

THE longer it takes to reach net zero, the greater the risk global warming will continue for decades or millennia even after we have in effect halted greenhouse gas emissions, says an assessment by climate researchers.

This means we may have to emit even less carbon dioxide than we thought if we want to limit warming to, say, 2°C, making carbon budgets even smaller than current estimates. "The timing at which we reach net zero is also key," says Roland Séférian at the National Centre for Meteorological Research (CNRM) in France.

Climate modellers once assumed that CO_2 levels would remain roughly constant after emissions ceased. In such scenarios, oceans would continue to warm for decades, leading to further surface global warming.

But more than a decade ago, modellers realised that, in fact, the oceans will continue to soak up some of the extra CO_2, leading to a gradual fall in atmospheric levels and less of the sun's heat being retained. Recent climate models suggest that, by coincidence, this cooling effect balances out the ocean warming, meaning surface warming halts within a few years of emissions stopping.

Not all climate models are the same, however. Standard climate models don't include all feedbacks, such as how much carbon is taken up by plants on land. More comprehensive "Earth system" models suggest that if, say, emissions stop when the world is 2°C warmer than pre-industrial times, there is a 33 per cent chance that the planet would continue to warm past 2.3°C.

"This means reaching net zero becomes even more important as a milestone"

Yet this still isn't the full story. Even the Earth system models don't include all feedbacks, such as the melting of the ice sheets on Greenland and Antarctica.

Séférian and his team have now done a comprehensive assessment of the uncertainties over timescales of decades, centuries and millennia. They looked at 26 factors that could lead to more warming or cooling, from the loss of forests and the melting of permafrost to shrinking ice sheets and changing ocean currents (*Frontiers in Science*, DOI: 10.3389/fsci.2023.1170744).

For about a third of these factors, such as some cloud responses and the extent of sea ice loss, we have no firm knowledge and can only speculate, say the researchers.

While some of the factors are expected to cause cooling, there is a general tendency towards extra warming on the timescales studied, says team member Joeri Rogelj at Imperial College London. "Peak warming could be higher with additional impacts, damages and challenges," he says. "It really means that reaching net zero becomes even more important as a milestone."

Additional warming doesn't mean unstoppable warming, says Rogelj. It could be prevented by continued carbon removal after net zero, for instance.

But in a comment accompanying the paper, Michael Mann at the University of Pennsylvania points out that carbon removal at the scale and speed required for halting warming might not be possible. "What is most urgently required is a rapid phaseout of human-induced activities that produce carbon pollution," he writes.

"Our understanding of how much the world will warm or cool after we hit net zero is still uncertain," says Zeke Hausfather at Berkeley Earth, California. "While our best estimate is that warming will stop when emissions stop, it's also possible that the world might continue to modestly warm – or modestly cool – after net zero." ▮

Health

Vitamin B3 could treat chronic pain

A high dose seems to work against persistent pain in mice, but human trials are still needed

Grace Wade

A KIND of vitamin B3 called nicotinamide riboside alleviates persistent pain in mice, suggesting that it may treat chronic pain in humans as well.

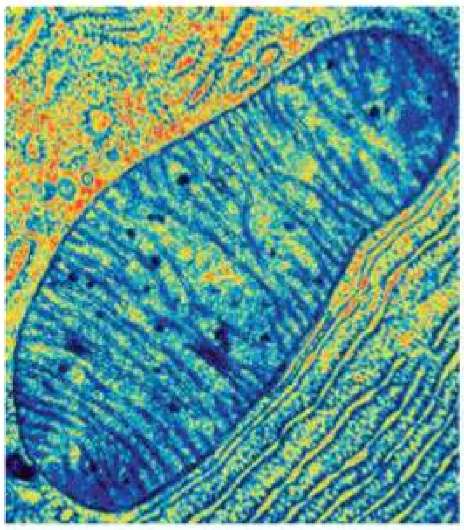
Inflammation – the body's first line of defence against injury and pathogens – is a main driver of pain. Yet some people continue to feel pain even after inflammation has resolved.

To understand why, Niels Eijkelkamp at Utrecht University in the Netherlands and his colleagues analysed inflammation's impact on mitochondria, the powerhouses of cells. Previous research has linked chronic pain to dysfunctional mitochondria, particularly those in specialised nerve cells called sensory neurons, which detect changes in the environment.

The researchers injected a substance that triggers inflammation into the hind paws of 15 mice. They then measured the amount of oxygen consumed by mitochondria in the sensory neurons of the animals, which indicates mitochondrial function. They found that a week later, after inflammation had resolved, the mitochondria consumed significantly more oxygen than they had before the injection, suggesting inflammation caused lasting changes. Further experiments linked these changes to greater pain sensitivity in the rodents even after the inflammation had subsided.

The researchers then analysed the molecular byproducts, or metabolites, of chemical reactions inside the mitochondria of the animals. They compared these with mitochondrial metabolites in mice that hadn't experienced induced inflammation. After inflammation had gone, mice had lower than expected levels of nicotinamide riboside in the mitochondria of their sensory neurons. This type of vitamin B3 is critical for mitochondrial function.

The mitochondria in certain sensory neurons could be linked to chronic pain



K.R. PORTER/SCIENCE PHOTO LIBRARY

So, about a week after inducing inflammation in a separate group of 12 mice, Eijkelkamp and his team gave half of them a high dose of nicotinamide riboside – 500 milligrams per kilogram of body weight. By comparison, the recommended daily amount of vitamin B3 for most human adults is 14 to 16 milligrams.

They then assessed the animals' sensitivity to pain by measuring how quickly they pulled their paw away from heat. Mice that hadn't received nicotinamide riboside retracted their paw twice as fast, on average, as those that had, suggesting the supplement alleviates pain (*Cell Reports Medicine*, doi.org/k4xh).

Together, these findings indicate two things: first, that inflammation can impair mitochondrial function in sensory neurons and this increases the risk of chronic pain, even after inflammation has resolved. Second, that taking nicotinamide riboside supplements may help treat this chronic pain by restoring mitochondrial function.

However, people with chronic pain shouldn't rush to take these supplements. "[This research] is still in rodents. How does it translate to humans? We really have to see that first," says Eijkelkamp. Clinical trials may show nicotinamide riboside has no effect or has unintended consequences, he says.

Even if these findings do translate to us, they probably only apply to certain types of chronic pain, says Eijkelkamp, such as the more than 20 per cent of people with rheumatoid arthritis – a chronic condition characterised by persistent joint inflammation – who continue to have pain even with low levels of inflammation.

Environment

Rainforest loss could worsen El Niño and La Niña

CUTTING down rainforests for palm oil in Indonesia and Malaysia could lead to longer El Niño and La Niña events with big climate impacts.

An El Niño event, like the one that began earlier this year, occurs when easterly trade winds weaken, so warm water goes from the western Pacific back to the eastern Pacific and heats the atmosphere. In La Niña, the alternative phase of the El Niño-Southern Oscillation, stronger trade winds cool the Pacific. Research suggests that stronger and longer-lasting El Niño and La Niña events are getting more frequent, and human-caused global warming is partly to blame. Now, Jin-Yi Yu at the University of California, Irvine, and his colleagues suggest deforestation could also contribute.

They have modelled what would happen if all the rainforests in the islands of South-East Asia were cut down. This showed that the islands would become drier and hotter, and more warm air would rise into the atmosphere there. This boosted circulation would intensify trade winds blowing south-west from Mexico, starting a feedback loop to strengthen winds more.

As a result, the frequency of multiyear – as opposed to single-year – La Niña events increased from 79 per cent of the time with the real-world vegetation to 88 per cent with the deforestation. Multiyear El Niño events also rose, but only from 40 to 45 per cent of the time (*Geophysical Research Letters*, doi.org/gs3zkk). Longer La Niñas and El Niños can have serious climate effects, like deadly drought.

"Cutting trees is another way to profoundly change how our climate machine operates"

"Beside burning [fossil fuels and] releasing carbon dioxide, cutting trees is another way to profoundly, significantly change how our climate machine operates," says Yu.

The findings raise further concerns about rainforest loss, but the effect of deforestation on El Niño and La Niña is small compared with the impact of greenhouse gases, says Michael McPhaden at the US National Oceanic and Atmospheric Administration.

Alec Luhn

Space

Plants thrive in lunar soil with help from bacteria

Alex Wilkins

GROWING plants on the moon could be made easier by adding bacteria to the soil to produce phosphorus, an essential element for growth.

Lunar regolith, the powdery dust that sits on the moon's surface, isn't great for plants. Researchers have grown thale cress, a small flowering plant, in real lunar regolith collected from the Apollo missions, but these were small and stunted, mainly because of the lack of nutrients that plants need for growth.

Now, Zhencai Sun at China Agricultural University in Beijing and his colleagues have found that three strains of phosphorus-producing bacteria can improve the nutrient profile of simulated lunar soil by converting calcium phosphate, which plants can't easily use, into bioavailable phosphorus.

Sun and his team added the three species – *Bacillus mucilaginosus*, *Pseudomonas fluorescens* and *Bacillus megaterium* – to the soil and, after three weeks, all three increased phosphorus levels by more than 200 per cent.

Tobacco plants (*Nicotiana benthamiana*) had longer stems and roots after growing for six days in soil containing these bacteria than did plants that were grown in soil without the bacteria. The plants grown in soil with the bacteria also grew four times heavier than their counterparts. Levels of chlorophyll, the pigment that plants use to convert light to chemical energy, were more than 100 per cent higher in the three bacteria-laden samples after 24 days (*Communications Biology*, doi.org/gs4dtp).

It is a useful study, says Karl Hasenstein at the University of Louisiana at Lafayette, but it may be even better to combine many microbe species to create a good nutrient profile, similar to soil on Earth, which can contain thousands of bacterial species producing a range of nutrients. ▮

Analysis **Artificial intelligence**

Actors' strike ends – but AI battle may not be over

An agreement on the use of digital replicas has ended the Hollywood actors' strike, but the industry could still drastically change, says **Jeremy Hsu**

ETIENNE LAURENT/EPA-EFE/SHUTTERSTOCK

An actors' strike in front of Netflix headquarters, Los Angeles, on 8 November

ARTIFICIAL intelligence has made its way into Hollywood and it may be here to stay. The use of AI to create digital likenesses was a major sticking point in the longest actors' strike in history, which has ended with a tentative agreement over the use of performers' digital twins. This means Hollywood can get back to work, but it may have also opened a new can of worms.

The collective bargaining agreement for performers requires film and TV companies to ask permission to make digital replicas of actors using AI or other technologies, along with providing compensation, said Duncan Crabtree-Ireland, chief negotiator for the Screen Actors Guild and the American Federation of Television and Radio Artists (SAG-AFTRA), in a *Rolling Stone* interview. SAG-AFTRA announced the agreement and the end of its almost four-month-long strike on 8 November, with its national board approving the overall agreement by 86 per cent.

That same agreement also provides for a minimum wage increase and allows performers to potentially share more of the revenue from streaming platforms. Studios would also need to seek permission from the estates, heirs or beneficiaries of deceased performers and provide compensation before using their digital likenesses. Such safeguards would "prevent a lot of people's worst-case scenarios about AI and film", says Kate Fortmueller at Georgia State University in Atlanta.

The agreement, which covers SAG-AFTRA's 160,000 members, provides a "baseline of informed consent" about the creation and use of digital replicas, says Fortmueller. But she cautioned that it doesn't appear to give additional power to actors or background performers in negotiating terms if they aren't at Scarlett Johansson or Cillian Murphy levels of fame and fortune.

> "It will be interesting to see the impact on living actors when roles may be filled by virtual ones"

There are also exemptions for getting consent if the digital performance "remains substantially as scripted, performed and/or recorded". Loose interpretations of this by studios could allow them to change subtle aspects of the original performance, said Justine Bateman, a writer and director, in a social media post.

The new agreement also covers generative AIs that could create entirely new "synthetic performers" not based on identifiable human actors or their voices. Studios that want to completely replace humans with synthetic performers in any roles would need to give SAG-AFTRA "an opportunity to bargain in good faith over appropriate consideration", but Fortmueller says that the language is vague and doesn't guarantee bargaining would take place.

Expanding the use of digital actors could also limit opportunities for living performers, even if actors and their estates are compensated and credited for use of their digital likenesses. "It will be interesting to see the degree of impact on living performers when roles may be filled by virtual versions of living and deceased actors," says Ryan Meyer at US law firm Dorsey & Whitney LLP.

Actors haven't been the only creative professionals negotiating on the use of AI. The Writers Guild of America, which represents film and TV writers, has also negotiated guaranteed protections against AI infringing on their work in a collective bargaining agreement with studios and streaming companies.

Now that production can continue on TV and film, some actors may be breathing a sigh of relief. But it remains to be seen how their profession will hold up as more digital replicas and completely AI-generated performers take the stage. ▮

Astronomy

The most distant black hole ever seen

Supermassive black hole 31 billion light years away could help settle an early cosmic mystery

Leah Crane

ASTRONOMERS have found the most distant black hole ever confirmed, at more than 31 billion light years from Earth. This object and others like it could finally settle the question of how supermassive black holes got so enormous so quickly in the early universe.

Priyamvada Natarajan at Yale University and her colleagues spotted the galaxy UHZ-1 in data from the James Webb Space Telescope (JWST). They then pointed the Chandra X-ray Observatory in the same direction to confirm the presence of a supermassive black hole at the centre of the galaxy.

"Many distant black holes are being detected and claimed with James Webb data, but the special thing with this one is to really confirm and pin it down," says Natarajan. "X-ray has always been the way we know for sure that we have a black hole – it's dead cert, no ambiguity." No other black hole this distant has ever been confirmed with X-rays before.

The extreme distance to UHZ-1 means we are observing it as it was about 470 million years after the big bang, when the universe was only about 3 per cent of its current age. The observations indicate that the black hole probably has a mass between 10 million and 100 million times that of the sun (*Nature Astronomy*, doi.org/k4nj; *The Astrophysical Journal Letters*, doi.org/k4nk).

> "X-ray has always been the way we know for sure that we have a black hole – it's dead cert, no ambiguity"

The combination of an early formation time and a huge mass makes this black hole particularly challenging to explain using traditional models of the formation of supermassive black holes. If it began as a star, which collapsed in on itself to become a black hole, it is hard to imagine how it could have got so massive in such a short period of time – even if the star was a particularly colossal one.

In recent decades, another possible formation mechanism has emerged: if enough gas flowed into the centre of a galaxy and then collapsed directly into a black hole, you could create a much heavier "seed" for a supermassive black hole to grow from. These heavy seeds could reach hundreds of thousands of solar masses, whereas the lighter seeds formed from stars couldn't get heavier than about 100 solar masses.

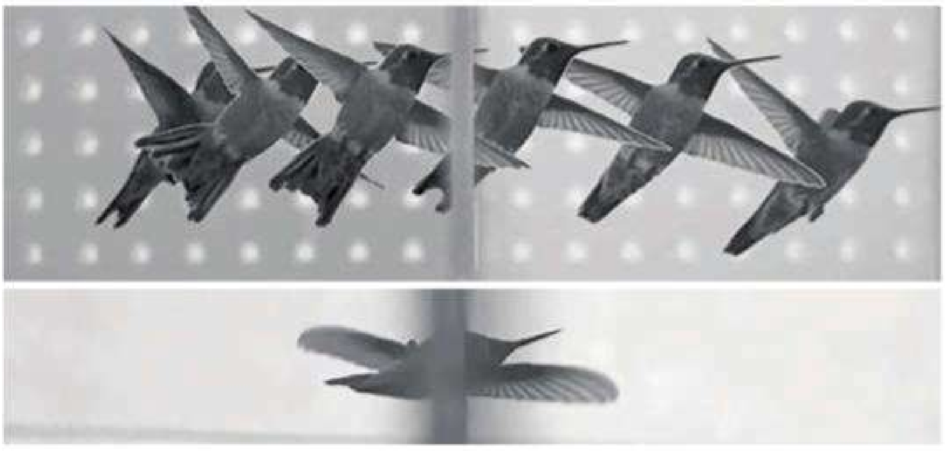
This black hole is one of the strongest pieces of evidence yet for the direct collapse model and the existence of heavy black hole seeds. "If it starts from a seed of roughly 10,000 solar masses, then we can reach the mass that we see in UHZ-1 very comfortably, with no extra constraints or caveats," says Natarajan. "This satisfies all of the requirements for being a heavy seed."

But satisfying all of the requirements doesn't make it a certainty, says Fabio Pacucci at the Harvard-Smithsonian Center for Astrophysics in Massachusetts. "If this is at 100 million solar masses, it's pretty big, but if it's at 10 million solar masses, it's not that big, so it could have possibly formed from a lighter seed," he says. "Everything hinges on finding more of these objects, possibly more massive, possibly at even higher distances, to really understand how the first population of black holes formed."

The good news is that JWST is uniquely equipped to find these black holes, and Chandra to confirm them, so those discoveries are likely to happen relatively soon, says Pacucci. ▮

Zoology

Hummingbirds have two ways to fly through tiny gaps



MARC BADGER

Shown from the side and below, one way hummingbirds navigate small gaps is to fly sideways

HIGH-speed cameras have revealed how hummingbirds fit through tiny gaps, which happens too quickly for the human eye to properly see.

Hummingbirds feed on nectar and often fly through small gaps in cluttered foliage as they flit from flower to flower. When one of the birds does this, "it looks like it literally just teleported", says Marc Badger at the University of California, Berkeley. To investigate how it happens, he and his colleagues filmed at 500 frames a second as Anna's hummingbirds (*Calypte anna*) passed through a gap between two compartments, and tracked the position of each bird's bill and wing tips. The hummingbirds' wingspans were about 12 centimetres and the gap could be shrunk to just 6 cm wide.

The birds used two strategies. One was to approach the gap slowly, hover near and then travel through sideways. The other was to approach quickly, fold their wings back and shoot through like a spear, before opening their wings again (*Journal of Experimental Biology*, doi.org/k4wf).

The slower strategy tended to give way to the speedier approach as the birds became more familiar with the set-up. But a 6-cm aperture forced them to use the braver strategy immediately. Badger thinks the birds risk injury by hitting the edges of the hole with their wings while going sideways. With wings tucked in, this danger is reduced, so there is an incentive to use the faster technique if possible.

"Their amazing wings make them good at hovering and good at flying fast, but that means they have to cope in tight situations," says Christopher J. Clark at the University of California, Riverside. "The manoeuvres these birds do to navigate through tight spaces put them in a class of their own." ▮

Matthew Sparkes

Health

3.5 minutes of intense activity a day may keep your heart healthy

Clare Wilson

DOING just a few minutes of vigorous physical exertion per day is linked with a lower risk of heart attacks and strokes, particularly among women who don't deliberately exercise.

This kind of unplanned activity would include running for a bus or doing heavy gardening or household chores, which suggests people don't need to go to the gym to improve their heart health, says Emmanuel Stamatakis at the University of Sydney, Australia.

The benefits were greatest among women who reported doing no planned exercise, but they were also seen to a lesser extent in both men and women who were regular exercisers.

Physical activity has a host of health benefits, including reducing people's risk of heart disease, dementia and weight gain. Most guidelines say we should aim for much longer periods of it than a few minutes a day, often recommending 75 minutes a week of vigorous exercise. One definition of this is that it stops you from being able to say more than a few words without pausing for breath.

Alternatively, people can aim for 150 minutes a week of moderate exercise, which England's National Health Service says is when people can still talk, but not sing.

Most of our knowledge about the benefits of exercise comes from people filling in questionnaires about how much they do. But Stamatakis and his colleagues have analysed data from the UK Biobank study in which thousands of people were asked to wear activity trackers called accelerometers for a week. Their health was then monitored for the next eight years.

LJUBAPHOTO/GETTY IMAGES

A last-minute dash can get your heart rate up enough to boost health

The team was particularly interested in people who reported that they normally carried out no deliberate exercise at all. The tracking devices showed that some of these people did experience periods of vigorous physical activity, presumably from things such as climbing stairs.

Among the women in this group, those who averaged about 3.5 minutes a day of this kind of exertion had nearly half the risk of experiencing a cardiovascular event, such as a heart attack or stroke, than those who got no such activity (medRxiv, doi.org/k4wc).

> "Unplanned activity would include running for a bus or doing heavy gardening or household chores"

However, this wasn't seen in the non-exercising men in the study. This may be because women generally have lower aerobic fitness than men, so a given amount of activity recorded by the accelerometers would have been more taxing for them and therefore yielded more health benefits, says Stamatakis. This is a plausible explanation, says Paul Hough at Oxford Brookes University, UK.

When the team considered people who deliberately exercised each week, the effect of short bursts of vigorous activity was there for men and women, but was smaller, cutting the heart attack and stroke risk by about 20 per cent. "If you're a regular exerciser, climbing stairs here and there is not going to be as beneficial," says Hough.

The study doesn't prove that bursts of vigorous activity protect the heart because it wasn't a randomised trial. An alternative explanation is that people who already had heart disease were less likely to exert themselves by running for a bus, for instance.

But the researchers reduced this source of bias by excluding people from their analysis who already had any heart conditions or developed them in the first two years of the study period, says Stamatakis. They also adjusted their figures to ensure that participants had similar risk factors, such as diet, income and smoking status. "We narrowed down our results to something that likely reflects causation," he says. ▮

Archaeology

Ancient Europe was full of savannah and grazed by elephants

Michael Le Page

THE natural state of Europe's forests was far more varied than we thought, with lots of grassland and light woodland as well as the dense tree cover of popular imagination, according to a study of ancient pollen. This could be because of the activity of many large mammals.

"On average, in each place that we looked at, over half the vegetation was open or light woodland. Imagine a kind of savannah landscape," says Elena Pearce at Aarhus University in Denmark.

To chart the ancient state of the continent's forests, Pearce and her colleagues analysed nearly 100 pollen samples from around 115,000 to 130,000 years ago from locations across Europe, from the Arctic to the Mediterranean. This is before humans were a dominant factor in shaping the landscape.

The researchers used a computer model that takes account of factors such as how much pollen different plants produce to predict vegetation cover and found that, in the past, it varied greatly both in geographic area and over time. This variability couldn't be explained by climatic factors or fires, they discovered (*Science Advances*, doi.org/k4wd).

That leaves megafauna, including straight-tusked elephants and rhinoceros, as the most likely explanation, says Pearce, since they suppress woody vegetation by eating and trampling young trees.

She thinks conservationists who want to restore the ancient forest biome should aim to recreate the processes that led to this landscape, rather than trying to reproduce the landscape itself. For instance, animals such as wild boar that dig up the ground help prevent species such as stinging nettles becoming dominant. "They're basically just messy, and all that mess creates brilliant habitats for things to thrive in," says Pearce. ▮

Nuclear fusion

Fusion may find first use in medicine

Reactors could make radioactive isotopes for hospitals before becoming useful power generators

Matthew Sparkes

THE first useful application of fusion reactors may be to create radioactive isotopes for cancer treatment or medical imaging rather than to generate energy, claims a UK start-up firm.

Scientists and engineers have worked on building a fusion reactor for a century, and a practical fusion power station is still thought to be decades away.

But Astral Systems is working on tiny fusion reactors that don't attempt to generate large amounts of power. Instead, they will create radioactive isotopes, which are used for a range of medical applications and are difficult and expensive to source.

Radioactive isotopes are used in two main ways in medicine: for killing cancer cells in radiotherapy and as radioactive tracers in the body to help spot medical conditions through imaging. Many of these isotopes have short half-lives, often just hours, so can't be stockpiled and must be created, transported and used quickly.

The source of these isotopes – which are essentially versions of atoms with a different number of neutrons – is a handful of more conventional fission nuclear reactors around the world. Because selling isotopes is less lucrative than running a large, modern reactor for power, and there are regulatory and safety hurdles to overcome in pulling samples from a reactor, it tends to be older sites that have made isotope production their niche.

LUIS ALVAREZ/GETTY IMAGES

Radioisotopes are used for imaging scans and in radiation therapy for cancer

The isotopes are produced by exposing certain elements to neutron bombardment inside the reactor, changing their nuclei by adding one or more of those neutrons, then capturing the resulting isotopes.

A UK government report in 2017 showed that just six reactors create more than 90 per cent of the world's medical isotope supply, and that all but one of these will shut down by 2030.

Astral Systems aims to build small fusion reactors that could be installed in regional isotope factories around the UK and the world, providing cheaper radioactive samples on a flexible timeline. The firm will use its reactors, which can already sustain fusion reactions, to produce neutrons to bombard other elements to create isotopes. The idea is to start with iodine-131, lutetium-177 and, later, actinium-225, but the firm will have to go through clinical trials before the isotopes can be used in medicine, says Tom Wallace-Smith, co-founder of Astral Systems.

Wallace-Smith says he recently spoke to staff of the UK's national health services at a conference. They told him they had a shipment of isotopes, with a half-life of about a week, held at the border in Calais, France. "Every week the isotope decays, so there's only half of it left. That package got held up for over a week, or two weeks, and then it was basically unusable as medicine," he says.

> "We've had weeks where we haven't had access to radioisotopes for regular medical scans"

There will be hurdles to leap before the isotopes can be sold as medical products, says Jennifer Young at King's College London, and the worldwide supply chain for isotopes is fragile. "We've had weeks, even during this year, where we haven't had access to radioisotopes and so NHS trusts haven't been able to do the regular nuclear medicine scans," she says. "So either they just scan very high-priority patients, but not as many, or they have to delay people, or people just don't get access." ∎

Astronomy

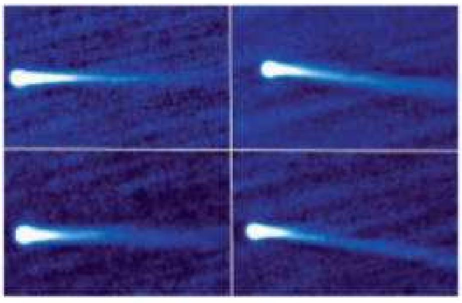
Comet Erasmus wagged its tail as it flew past the sun

A GUST of solar wind seemed to make a comet wiggle its tail as it passed by the sun. Observations of such phenomena could help us learn more about space weather in the region close to our star.

Comets are small, icy objects that whizz around the solar system. As they approach the sun, their frozen bodies melt and release a stream of gas and dust known as a tail.

In September 2020, astronomers discovered comet C/2020 S3, also called Erasmus, as it was hurtling towards the inner solar system. By December 2020, the comet reached its closest approach to the sun, at 0.4 times the distance between Earth and the star, just inside Mercury's orbit.

Using solar telescopes on the STEREO-A and SOHO spacecraft, Jing Li at the University of California, Los Angeles, and her colleagues tracked the comet. In the 34-hour period when the comet was closest to the sun, its tail swung like a pendulum, making a 30-degree angle on either side of the direction of travel (arXiv, doi.org/k4xz).


JING LI ET AL. (2023)/UC

The movement of comet Erasmus's tail, as seen by the STEREO-A spacecraft

"We saw that the tail had a very wide swing. That was unusual," says Li. This behaviour was probably due to an eruption of plasma from the sun, known as a coronal mass ejection, she says. Based on their observations, the researchers calculated that the coronal mass ejection that hit comet Erasmus was travelling at more than 200 kilometres per second.

"The study shows that it is possible to use comets as solar wind probes," says Dennis Bodewits at Auburn University in Alabama. It has been difficult to measure solar wind properties very close to the sun in the past because it is hard to send spacecraft there, he says. ∎

Chen Ly

Marine biology

Sea cucumbers put on a spectacular light show

Melissa Hobson

A DEEP-diving submersible has witnessed 10 sea cucumber species emitting light for the first time in their natural habitat.

The observations were "totally unexpected, like a spectacular movie", says Manabu Bessho-Uehara at Nagoya University in Japan. In the control room on the research ship, "nobody could say anything except 'wow'".

Sea cucumbers are animals in the same phylum as starfish, found on the ocean floor all over the world, and viewing their natural bioluminescence is hard. When you bring specimens onto a ship to examine them, conditions on board can disrupt their glow. "In the deep-sea environment, the pressure, temperature, light conditions, sound and chemical composition of the seawater: everything is different from the ship's seawater tank," says Bessho-Uehara.

So, he and his colleagues sent a remotely operated vehicle about 1000 metres down to the seabed around Monterey Bay, California, equipped with a camera and a robotic arm.

This revealed that in the animals' natural environment, light ripples down them from head to tail and back again like a wave – in contrast to bioluminescence seen in specimens on ships, which emit blue light all over their bodies (*The World of Sea Cucumbers*, doi.org/k4h7).

The bioluminescence is thought to be a defence mechanism if a sea cucumber is attacked, intended to attract a bigger, faster predator that might prey on the assailant.

Bioluminescence has now been observed in 26 of the 249 known sea cucumber species. Based on the evolutionary relationships between the species that glow, Bessho-Uehara and his colleagues estimate there could be over 200 glowing sea cucumber species in total. ▮

Health

Alzheimer's blood tests may be rolled out within five years

Clare Wilson

ANDREW BROOKES/GETTY IMAGES

Blood tests could speed up the diagnosis of Alzheimer's disease

DIAGNOSING Alzheimer's disease can be a difficult and lengthy process, but it could be aided by blood tests in the next few years.

Several such tests for Alzheimer's disease are used in research settings, but aren't yet routinely employed by doctors in most countries. Now, a project to see which one works best in the real world has been launched by a coalition of UK medical research funders.

Those involved predict that, by the project's end, in five years, they will have at least one test ready to be routinely used when people consult a doctor for memory problems.

"We expect, in the next five years, the pathway to somebody getting a diagnosis to be completely different," Susan Kohlhaas at charity Alzheimer's Research UK said at the project's launch on 8 November.

The team is confident of the project's success because the tests have good accuracy in research, said Joanne Rodda at the Kent and Medway Medical School in Canterbury, UK, at the launch event. We know these tests have an accuracy that is comparable to spinal fluid tests, which are currently used as part of the Alzheimer's diagnosis process, she says.

The tests used in research are usually based on various forms of two proteins involved in Alzheimer's. One, called beta amyloid, builds up outside brain cells. The other, tau, accumulates within the cells.

Several firms offer testing for an Alzheimer's-associated variant of each of these proteins to gauge whether someone may have the condition.

> "People who go to a doctor because of memory problems can take months or years to get a diagnosis"

The tests need to be assessed under real-world conditions because, although Alzheimer's can affect people of any income or ethnicity, those with the condition who take part in clinical trials are often white and have higher income levels than most of the population. The results may also be affected by diet or lifestyle, Fiona Carragher at the Alzheimer's Society in the UK said at the event.

The project to compare some of the different available tests, known as the Blood Biomarker Challenge, is being run jointly by the Alzheimer's Society, Alzheimer's Research UK and the UK's National Institute for Health and Care Research.

The impetus partly stems from the development of treatments that clear amyloid from the brain. Two drugs consisting of antibodies that bind to amyloid slightly slow the deterioration seen with Alzheimer's.

One, called lecanemab, is approved in the US for treating Alzheimer's, although to be eligible, people need to have a confirmed build-up of amyloid, usually from a brain scan or a sample of spinal fluid. This could be avoided if a blood test revealed raised levels of one of the amyloid variants.

It would also have other advantages, even before any new treatments become available, said Rodda. People who go to a doctor because of memory problems can take months or years to get a diagnosis, in a process that can involve cognitive tests and multiple brain scans.

Rob Howard at University College London says adding a blood test to diagnostic procedures would help people gain faster access to some treatments of Alzheimer's symptoms, such as drugs called cholinesterase inhibitors. But he says such tests shouldn't be taken without a doctor's involvement. For example, a consumer test is available to buy online in the US. "They are needed in the context of a proper clinical assessment," he says. ▮

Genetics

Artificial life grows a step closer

Strain of yeast with a genome that is 50 per cent synthetic is a significant advance

Michael Le Page

RESEARCHERS have created a strain of yeast in which half of its 16 chromosomes are synthetic ones redesigned from scratch, in a big step towards creating the first complex cell with an entirely synthetic genome.

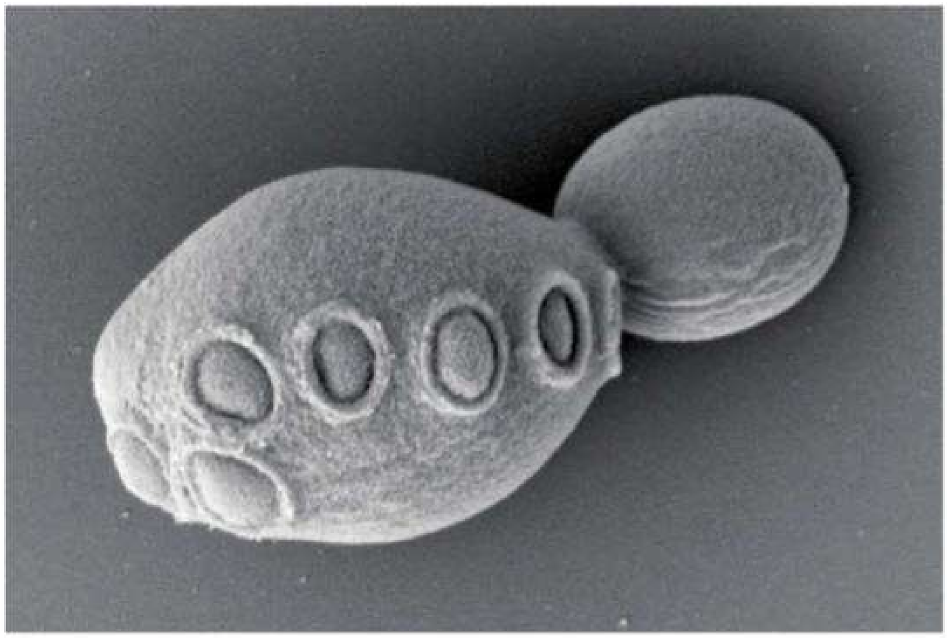
"We're more than halfway there now," says project leader Jef Boeke at New York University Langone Health. "It's going to be an amazing platform for optimising yeast for producing products that are useful to humankind."

Groups have created viruses and bacteria with entirely synthetic genomes, but yeast is more challenging because it is a complex or eukaryotic cell, like those in all plants and animals. Complex cells have larger genomes divided into chromosomes, rather than the small genomes typical of bacteria.

The synthetic versions of all 16 yeast chromosomes are now complete, but putting them all together in a single yeast strain could take another year or so, says Boeke. "When we get all those chromosomes into a single strain, we're going to be able to do a whole bunch of new things we couldn't do before."

The main issue is "debugging" the synthetic chromosomes. "As we build things, we discover these bugs, and these are the result of changes we intentionally made that, according to what we know about biology, should not have had a negative impact, but it turns out that they do," he says.

Yeast cells with a partially synthetic genome, viewed with an electron microscope



CELL ZH

Eukaryotic cells have more repetitive or "junk" DNA than bacteria. The team has removed most of this, making the synthetic chromosomes about 10 per cent smaller than those in wild yeast. "We believe that by removing repetitive DNA we will make a fundamentally more stable base for biotechnology," says Boeke.

The team has also added 3000 sites to the genome where they can trigger recombination, where pieces of code are exchanged between chromosomes. The idea is to rapidly evolve strains for industrial applications (*Cell*, doi.org/k4hq). "It's kind of like shuffling a deck of cards," says Boeke. "The scramble system is essentially evolution on hyperspeed, but we can switch it on and off."

There is also a new 17th chromosome, on which all the genes are aligned in the same direction. "There's nothing like that in nature," says Boeke.

Some researchers say the yeast should have a biocontainment system to ensure it couldn't survive in the wild.

"Even if remote, the risk of an escaped, potentially invasive synthetic organism is still a serious one," says Geoffrey Taghon at the US National Institute of Standards and Technology.

"Adding some sort of containment system to the final strain would be ideal," says Boeke. The team has already made changes that mean the synthetic yeast couldn't outcompete wild ones, he says.

Environment

The past 12 months were the hottest ever on record

THE period between November 2022 and October 2023 saw global average temperatures rise 1.32°C above the pre-industrial average – 0.03°C above the previous record for a 12-month period, set between October 2015 and September 2016.

"This is the hottest temperature our planet has experienced in something like 125,000 years," says Andrew Pershing at Climate Central, a US climate science non-profit organisation.

Pershing and his colleagues analysed surface temperature data from the European Centre for Medium-Range Weather Forecasts and found that the main driver of the heat was global warming due to rising concentrations of greenhouse gases in the atmosphere.

Attributing the exact amount of warming to different factors is challenging, but Friederike Otto at Imperial College London says about 1.28°C of the rise in average temperatures can be attributed to climate change.

The team found much of the rest of the heat could be attributed to the shift to a warm El Niño climate pattern in the Pacific Ocean in June. "There's only a very small part of this 1.32°C that is natural variability," says Otto.

The researchers also used climate models to compare the likelihood of the extreme heat seen with and without the influence of human-caused climate change. During the period they studied, some 90 per cent of the world's population was exposed to at least 10 days with heat made substantially more likely by climate change. "It's really affecting every human on this planet. And it's mostly affecting the most vulnerable people," says Joyce Kimutai at the Kenya Meteorological Department.

> "It's really affecting every human on this planet. And it's mostly affecting the most vulnerable people"

With El Niño not expected to hit its peak until the next few months, Pershing says the coming 12 months are likely to be even hotter – possibly more than 1.4°C above the pre-industrial baseline.

James Dinneen

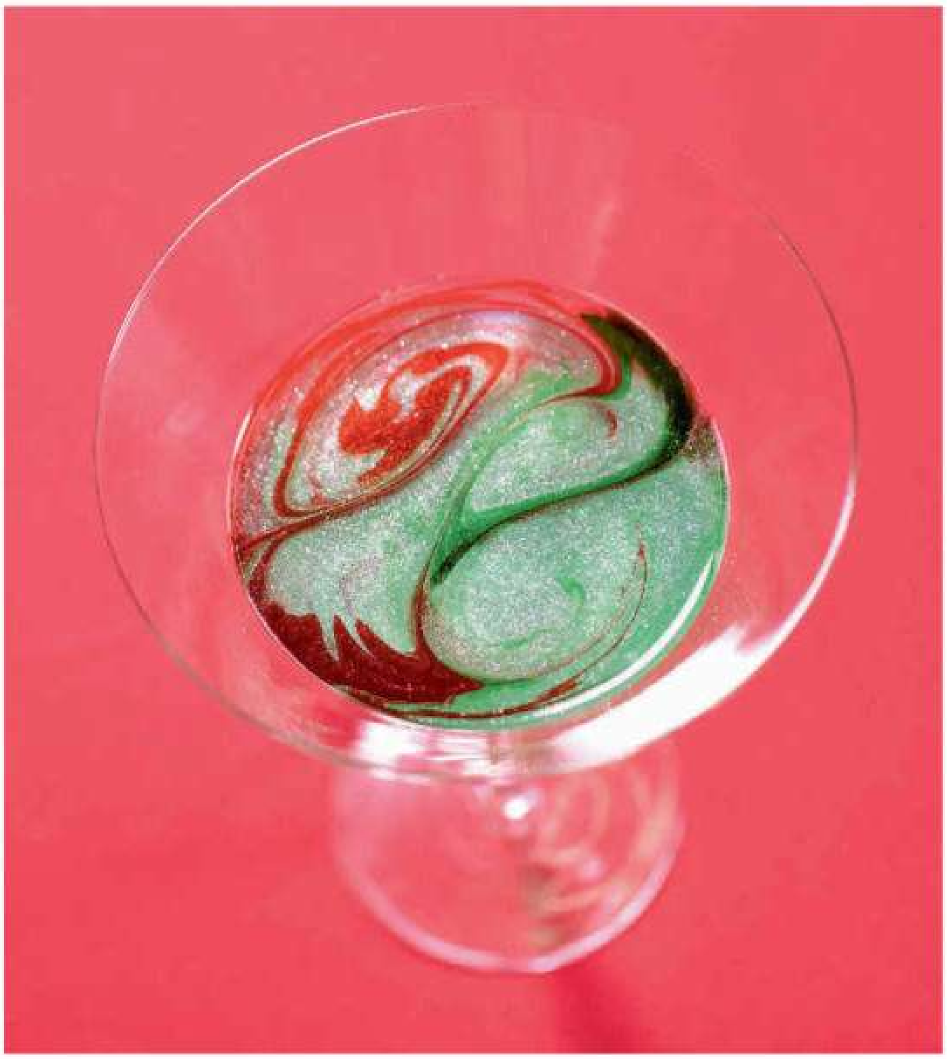
Astronomy

Milky Way-like galaxy is oddly old

ASTRONOMERS have spotted the earliest barred, spiral galaxy yet. It is the same type of galaxy as our Milky Way, but it dates back to when the universe was just 2 billion years old, earlier than was thought possible.

Cosmic formation models have suggested that such galaxies only started forming some 4 billion years after the big bang. Luca Costantin at the Spanish Astrobiology Centre and his colleagues have spotted the oddity in data from the James Webb Space Telescope and the Hubble Space Telescope, naming it ceers-2112 (*Nature*, doi.org/k4jx).

The galaxy's light has been travelling since 2 billion years after the big bang, which was about 13.7 billion years ago. Ceers-2112 is also the most distant barred, spiral galaxy ever seen. **Chen Ly**



XIANYU (MABEL) SONG/ZHAO PAN

Chemistry

Dissolving tracked at the atomic level

WE HAVE now seen exactly how solvents interact with dissolved materials, one atom at a time.

Henrik Stapelfeldt at Aarhaus University in Denmark and his colleagues used a nanoscopic droplet of liquid helium cooled to -255°C (-427°F) to dissolve an atom of sodium. They embedded a xenon atom in the helium, and the sodium atom sat at the droplet's edge. One laser pulse hit the sodium atom to make it positively charged and kick off solvation, so the helium atoms stuck to it.

Another pulse made the xenon atom positively charged too, repelling the sodium ion and its attached helium atoms into a detector. By changing the gap between pulses, the team took snapshots through time to create a molecular movie of the process (*Nature*, doi.org/k4jz). **Karmela Padavic-Callaghan**

Physics

New way of shaking a martini creates bold patterns

SHAKING a drink in a martini glass creates mesmerising swirls of small whirlpools.

Most people use a martini shaker to mix their drink before pouring it into a glass, or just stir it, but Zhao Pan at the University of Waterloo, Canada, and his colleagues have found that if you shake the glass back and forth, bubbles create a complicated structure of vortices (see picture, above).

They have shaken a range of mixtures, each with a different "Reynolds number" – a measure of the imbalance between particles in a fluid being propelled by inertia and getting slowed down by viscosity. For mixtures with a high Reynolds number – which you can achieve by adding syrup to a drink – shaking the martini glass produced a pattern of vortices that resembled elongated hearts when looking into the glass from above.

When the researchers shook liquids with very low Reynolds numbers (meaning they were less viscous), four symmetrical vortices emerged, producing an effect like a four-leaf clover with a small whirlpool at each petal's centre.

The researchers will present their photographs of the phenomenon at the American Physical Society's Division of Fluid Mechanics conference in Washington DC later this month.

Pan says that while the researchers don't yet have a good mathematical understanding of this effect, it might be related to better-studied areas such as how fluids slosh in moving containers – like the fuel in a ship's fuel tanks – and rip currents seen in coastal areas, where fluid also hits an inclined edge and reflects off it in a strong jet outwards. **KP-C**

Really brief

LAURA LAROCCA

Greenland glacier melt accelerates

Aerial photographs and satellite imagery show that glaciers in Greenland are retreating twice as fast this century as they were in the 20th century. The 821 glaciers receded 7.7 metres a year on average between 1890 and 1999, and 14.8 metres a year this century (*Nature Climate Change*, doi.org/k4jw).

Peanut toothpaste could halt allergy

Toothpaste infused with peanut proteins could help prevent an allergic reaction. Adults with a peanut allergy didn't have a reaction when exposed to peanut protein after they had used the toothpaste for 48 weeks, according to work presented at an American College of Allergy, Asthma and Immunology meeting.

Eyebrows give away faked photos

Suspiciously smooth eyebrows on a passport photo could be a giveaway that someone has doctored the image to outwit automatic face recognition at a border crossing. It can be a sign that photographs of two different people's faces have been merged together (arXiv, doi.org/k4mp).

EMERGENCY SURGERY

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Jessica Comi (left) and MSF surgeon Dr Federica Lezzi extract a bullet from a patient shot just above the knee during fighting in the Sudanese capital. Bashair hospital, Khartoum, 13 May. Photograph © Ala Kheir/MSF

JESSICA COMI IS AN OPERATING THEATRE NURSE WHO WORKED FOR MSF IN KHARTOUM, SUDAN.

"We arrived in Khartoum on a Monday and started operating at noon the following day. The first week was incredibly challenging.

Every time we heard explosions, we got ready for a mass casualty incident – a situation where lots of wounded people arrive at the same time. You never know if it will be 20 or 40 or 100 patients. One day, 127 patients arrived in a short space of time after a series of explosions.

Very quickly we were inundated with wounded men, women and children. Seventeen people were dead on arrival. The emergency room was full, the two operating theatres were full. In one theatre, we were trying to manage the most complex cases; in the second, we were working on cases that were a bit less complicated. That day, we ran the operating theatres until four or five in the morning. We worked non-stop.

War surgery is complicated. Working with wounded patients brings a lot of challenges and, if you aren't used to doing this type of surgery, it can be especially difficult. You need to know the potential risk for a patient if they are not treated immediately – risks such as infections or losing a limb or haemorrhaging. Bullets and shrapnel are dirty and they create massive wounds, so in a war zone you treat every single wound as already infected. These injuries are complex and you need to act quickly. Our team was experienced and that expertise made a big difference.

Depending on the kind of wound, some patients need multiple surgeries and can take many days to recover. Others may need even longer treatment – taking weeks or sometimes months.

As the conflict continued and more people heard that the hospital was open, we started to see more patients, particularly women and children.

I have worked a lot in war zones, and this was probably my most challenging assignment. But it was very special how the team worked through the challenges together. You could feel that we were all working for one reason – and that was to save lives."

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Views

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Old coal mines could help green tech, says **Graham Lawton** p22

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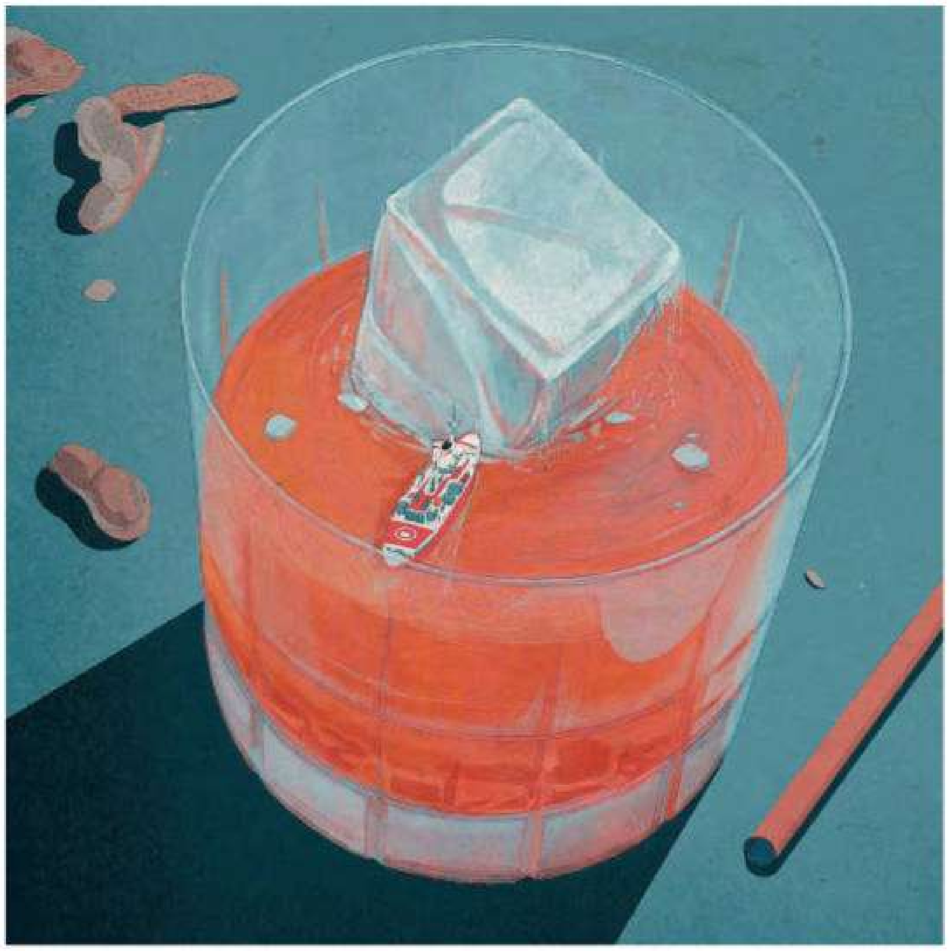
A new book asks what darkness is and why it frightens us p28

Culture
How the everyday toxins we imbibe have shaped the world p30

Comment

'Water become bone'

Once seen as miraculous, for all its ubiquity, ice is still an enigmatic, surprising substance, We should cherish it more, says **Max Leonard**



SIMONE ROTELLA

IN THE past year, we discovered an entirely new kind of ice. Frozen water is usually found with its atoms arranged in a regular tetrahedral lattice. But if you chill it to -200°C and bombard it with small steel balls, the ice becomes disordered and amorphous.

In fact, there are two other amorphous types of ice (high and low density – this new one has a medium density, almost the same as that of water), and we also know of at least 18 crystalline "phases" other than regular ice, strange configurations that exist fugitively under high pressure in lab conditions, in Earth's mantle or in space. The most recent of these was only fully described in 2021. More phases are proposed and no doubt will be found.

It might seem weird that we are still discovering new things about ice, but it is somehow both bizarre and fitting that H_2O is still so poorly understood. Water, the foundation of all life, is an exceptional substance. And since the start of human history, ice has been seen as miraculous. The 9th-century hermit Sebaldus is said to have performed a miracle and made fire from icicles en route to becoming the patron saint of Nuremberg. And a 10th-century Saxon riddle runs: "The wave, over the wave, a weird thing I saw, / through-wrought, and wonderfully ornate: / a wonder on the wave – water become bone."

By this period, it had been known for a thousand years in China that snowflakes are six-sided (people may have spied this using magnifying lenses), but this fact passed unnoticed in the West until the glimmers of the scientific revolution in the 17th century. In his pamphlet *De Nive Sexangula* in 1611, Johannes Kepler wondered if this six-sidedness was inherent, and considered the arrangement of seeds inside a pomegranate as a possible model for what was happening on an invisibly smaller scale. It was, you might say, our first glimpse of the building blocks of the universe.

Kepler wasn't alone in his curiosity. René Descartes also studied snowflakes, while Francis Bacon wrote: "whosoever will be an Enquirer into Nature, let him resort to a Conservatory of Snow or Ice". And later, in the mid-17th century, Robert Hooke revealed the stark beauty of this hidden world with his microscope.

But it is Hooke's contemporary Robert Boyle whose interest in ice was the most enlightening. In experiments conducted over a decade or more, he used ice as a tool to investigate the phenomenon of cold. (Heat is simple to produce, but cold is far more difficult to explain, or to conjure up.) Boyle also froze various substances, including food and drink – iced beer was "dispirited like phlegm", he found – experiments that presage a practice that is vital to the modern world.

These days, of course, ice is no longer extraordinary: it is a commodity we quietly grow in a small box in the corner of the kitchen and consume at will. A substance that is now figuratively as well as literally almost invisible to us. Yet, as the new discoveries show, there is still so much more to learn.

The news about medium-density amorphous ice came amid an Antarctic winter season in which maximum sea ice extent hit a historic low. These facts aren't connected, but to me, at least, they throw each other into sharp relief. Ice has been our companion throughout history in our attempts to live in and make sense of the world, crucial to our appreciation of both the strangeness of the cosmos and its fundamental order. What if we are losing even more than we can know?

Perhaps we should all try to see, in the mundane ice cubes that clink in our drinks, something of the awe and mysticism of our earliest encounters with ice, in order that we might cherish and protect it better. ■

Max Leonard is the author of *A Cold Spell: A human history of ice*. @m_xl

No planet B

Old King Coal Coal waste separation might sound deathly dull, but the waste from abandoned coal mines could provide rare and crucial elements for clean energy tech, discovers **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

Graham's week

What I'm reading

Discover Dorset: Fossils *by Richard Edmonds.*

What I'm watching

The Fall of the House of Usher *on Netflix.*

What I'm working on

Planning a blustery walk on the beach.

I AM writing this column from Lyme Regis on the south coast of England, a place very dear to my broken heart, and not just because I am a fossil hunter. My late wife and I spent many a happy holiday here pottering about looking for ammonites.

Now would be an unwise time to do the same. Just before I arrived, the town was battered by Storm Ciarán, causing several cliff collapses and leaving the beaches vulnerable to more. But yesterday was like summer; I swam in the perfectly flat sea. Today, it is lashing with rain. Something very weird is going on with the weather. Why could that be?

Whether Storm Ciarán was caused or intensified by climate change isn't yet known. But it is clear we need solutions, fast. I heard about an innovative and promising one a few weeks ago, and I want to focus on that. On the surface, it sounds deathly dull – I immerse myself in this stuff so you don't have to – but bear with me.

The technology is called coal waste separation and I heard about it in a webinar hosted by the US National Academies of Sciences, Engineering, and Medicine. In a nutshell, this means cleaning up old coal mine waste for ecosystem restoration. That is great in and of itself. But there are three other potentially massive upsides.

The US has thousands of abandoned coal mines, often heavily contaminated with coal refuse called tailing waste (or slag heaps as we charmingly call them in the UK), as well as ash ponds where the waste from burning coal is stored. They are largely left as they stand, perpetuating the toxic legacy of fossil fuel production.

But according to Jennifer Wilcox at the Office of Fossil Energy and Carbon Management within the US Department of Energy, these "wastes" are anything but. Coal contains a lot of useful stuff besides chemical energy, and when it is burned, these compounds are left behind and concentrated. Tailing waste and ash ponds are, if not a gold mine, then at least a lithium one.

Lithium is one of the "dynamic dozen": 12 elements and minerals that are central to clean energy technologies ranging from wind turbines to electric vehicle batteries. The other 11 are cobalt, dysprosium, gallium, germanium, graphite, iridium, manganese, neodymium, nickel, platinum and praseodymium.

> **"Coal ash in the US contains around 288,000 tonnes of lithium, enough to supply its market for 130 years"**

The US has pledged that 100 per cent of its electricity will be generated from clean energy technology by 2035. Achieving that will require many of the dynamic dozen. But there are long-standing worries about their global supply and the environmental damage of their extraction. Much of the resource is in China, Indonesia and the Democratic Republic of the Congo, which the International Energy Agency has described as "a concern from a geopolitical point of view".

Enter Old King Coal. Coal waste (in the US at least) contains absolutely tonnes of the stuff. Coal ash alone contains an estimated 288,000 tonnes of lithium, enough to supply the US market for 130 years. It is also rich in cobalt, neodymium, dysprosium, platinum, iridium, gallium and germanium. The last two of these are needed for the semiconductors that will be used in sensors and controllers for the clean tech.

"It's significant enough to meet some of these clean energy targets that we have," said Wilcox in the webinar. "I'm really excited."

There are other reasons to be excited. Not only does coal waste contain those crucial elements, some of it is rich in magnesium and calcium. These aren't being lined up for extraction, but as a material for negative emissions tech. Coal waste containing magnesium and calcium reacts with carbon dioxide and locks it away as solid carbonates.

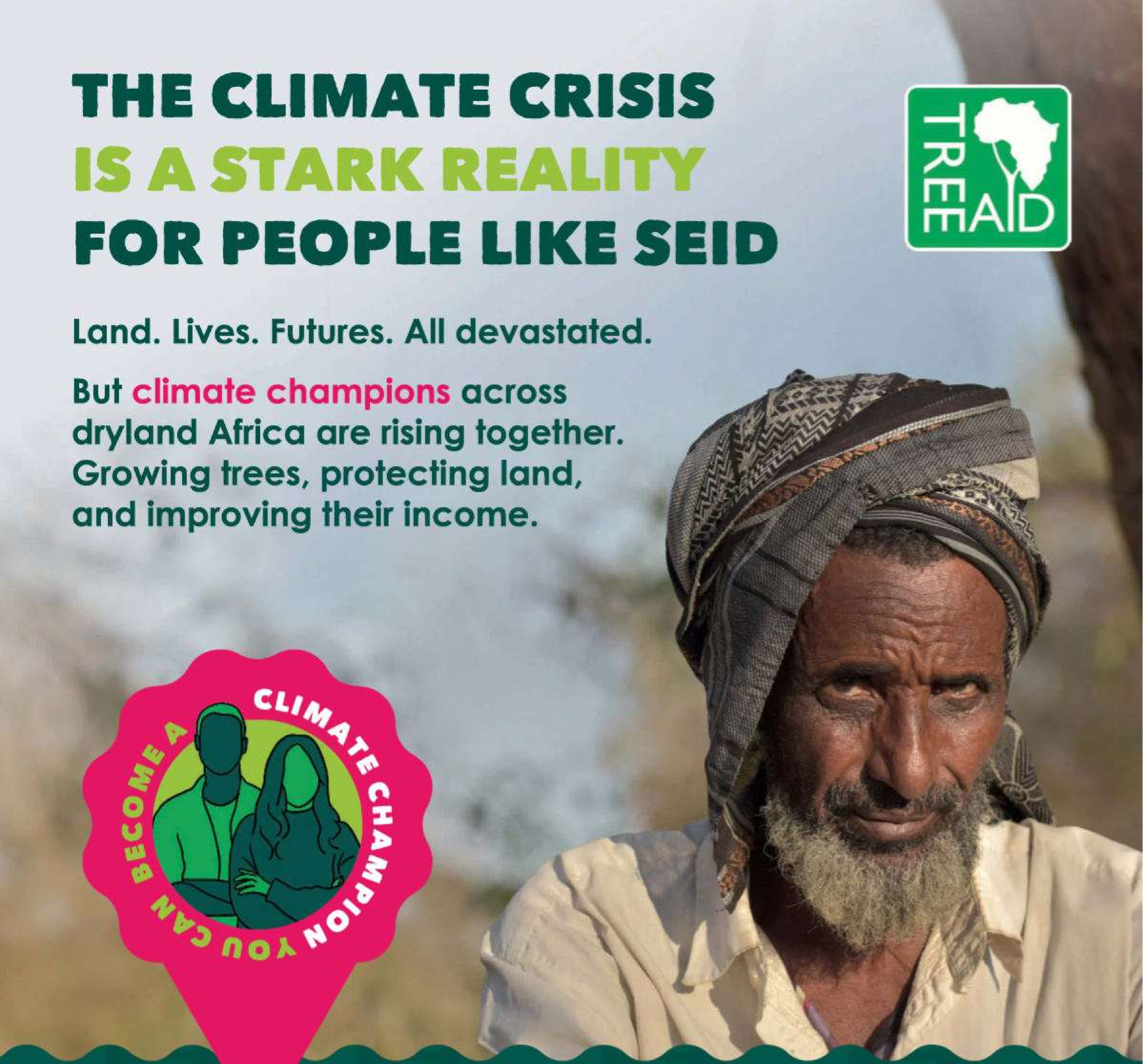
Coal waste is also often situated in communities blighted by the loss of jobs in mining. They need new jobs and often have the skills that will be required to develop a minerals extraction industry. Win, win, win, win.

But there is a way to go. The purity of the elements is typically modest, said Wilcox, and the separation technologies to recover and refine them are in their infancy. The cost of doing so is also unknown. But the US Department of Energy is burning the midnight coal to work out how to do it.

And if coal doesn't work out, there are other unconventional feedstocks that could be tapped. These include asbestos mine tailings, "red mud" from aluminium production, brines from geothermal power plants, phosphogypsum wastes from phosphoric acid and fertiliser production, e-waste, conventional landfills and even sewage sludge.

Of course, if the US does develop a coal waste separation industry, it is unlikely to share the bounty. But many other countries, including the UK and Germany, have plenty of slag of their own. Coal may be on its way out, but its legacy could help to save us from the storms of our own making. ▮

This column appears monthly. Up next week: Annalee Newitz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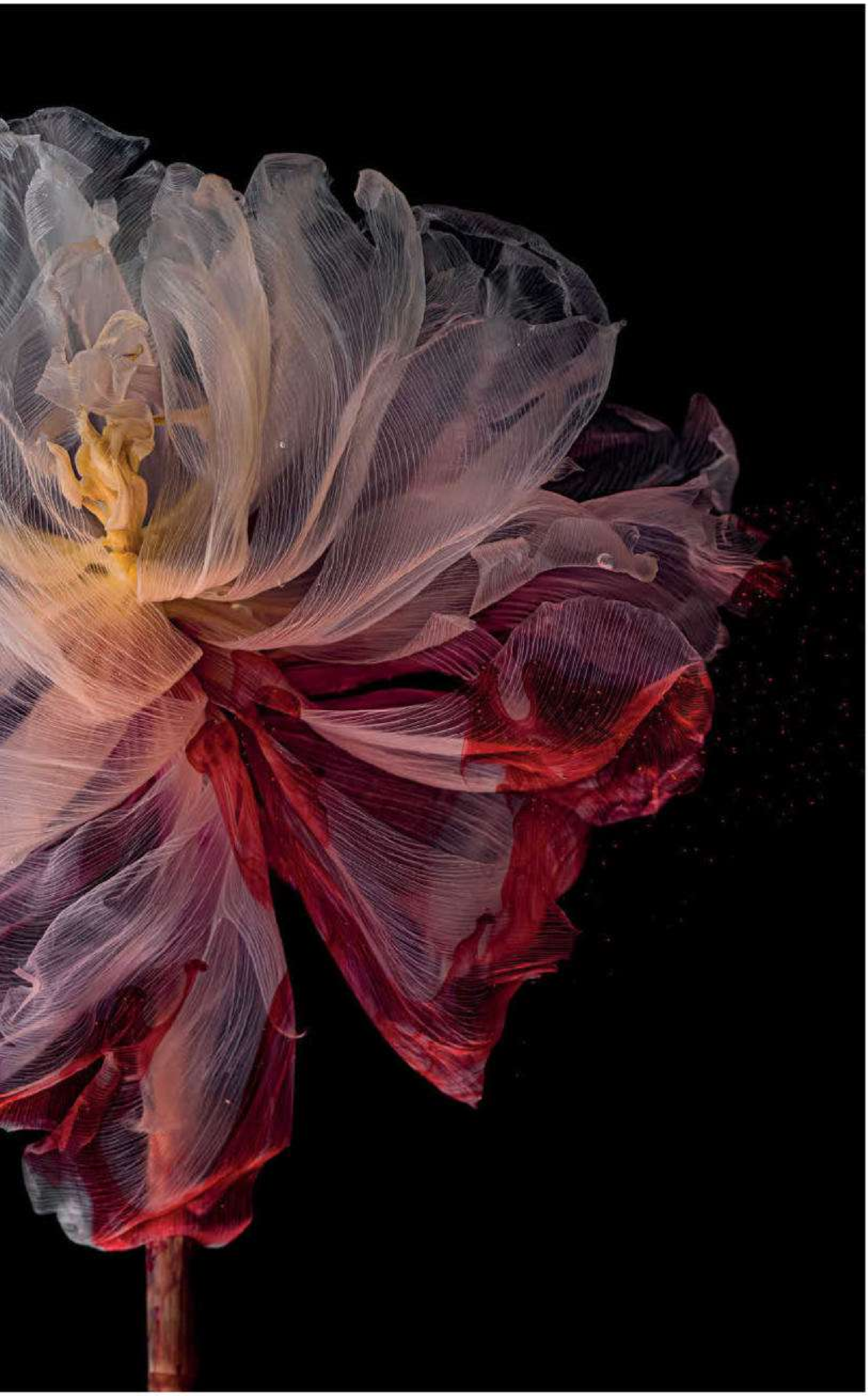

On the cusp

Photographer Kathrin Linkersdorff
Exhibitor Deichtorhallen Hamburg

THESE works from artist Kathrin Linkersdorff show how beauty is tucked away even, and perhaps especially, in life's imperfection and impermanence.

Linkersdorff's art is heavily influenced by the Japanese concept of *wabi-sabi*, which is all about how transience and imperfection are integral and beautiful parts of life. Drawing on the aesthetics of living organisms, such as flowers and bacteria, Linkersdorff evokes *wabi-sabi* in her works by capturing the cusp between life and death, preserving this state in a mesmerising display of colour and form.

The intriguing images shown here are part of Linkersdorff's series *Fairies*, for which she dried an assortment of tulips over several months, extracting their pigments and reconcentrating them into natural dyes using a method she developed over several years. She then suspended the flowers in liquid, where their petals would unfold, and often reintroduced the dyes into this liquid medium.

"The interaction between colour and shape becomes a poetic dance, revealing the hidden alchemy in all living matter," she says. "For me, pigment is an expression of life."

Fairies, and more of Linkersdorff's works, including her new *Microverse* series, will be on exhibition at PHOXXI, the Temporary House of Photography at the Deichtorhallen Hamburg in Germany, until 21 January 2024.

Gege Li

Editor's pick

Some good reasons to unleash the power of AI

11 November, p 11

From Will Cavendish, London, UK

Matthew Sparkes rightly urges governments to speed up putting detail on legislation and regulation to ensure the safe and responsible development of AI. But we shouldn't only worry about this aspect.

Where AI is already safe and responsible, we need to speed up its deployment and impact, as it is proving to be an "intelligence multiplier" in efforts to tackle climate change and the biodiversity crisis. At Arup, the sustainable development firm where I work, we already use AI to help cities cope better with rising rainfall and extreme heat, to avoid carbon emissions and to help track and improve biodiversity.

The destruction of climate and nature is happening now, and we need to harness the power of safe AI if we are to going to stop it.

Sperm oddity won't derail the order of the universe

28 October, p 14

From Sam Edge,
Ringwood, Hampshire, UK

Last time I checked, our theories of the universe would be down the tubes if anything could truly break Newton's third law of motion, aka the conservation of momentum.

The idea that sperm can do so reminds me of previous assertions that bumblebees violate the laws of aerodynamics. Upon detailed analysis, the flight mechanism is clear. And, in my view, so is the fluid dynamics involved in sperm propulsion. I don't believe either involve violations of physical principles as we understand them.

Chatbots may render critical thinking extinct

4 November, p 40

From Paul Bowden,
Nottingham, UK

We know that large language model chatbots can't be trusted to always tell us the truth. We now find that it is hard to get them to "unlearn" concepts and facts without retraining on "cleaned" data, a wholly impractical task.

One wonders what the next problem could be. I suggest it will be a growing realisation that human critical thinking is in decline, as the need to ponder an issue fades. Why bother thinking it through and writing it up if you can just ask a chatbot to do it?

Language's power to shape our mindset is writ large

4 November, p 29

From HildaRuth Beaumont,
Brighton, UK

A novel by Jack Vance pre-empts, to some extent, the language-shapes-mindset view of Caleb Everett in his book *A Myriad of Tongues*. Vance's *The Languages of Pao* tells the story of the placid people of the planet Pao.

These people have been invaded, so they adopt three new languages to reform their society and repel the aggressors. One is scientific and leads to more innovation, one is orderly and encourages a strong work ethic, while the third promotes war and violence. This linguistic overhaul allows Pao's people to oust the invaders and improve their planet's economy.

Ditch the spritz and keep plants in good health

4 November, p 44

From Nick Hazel, York, UK

Previous research I was involved in showed that aerosol sprays don't linger, as James Wong found with water sprayed on plants. I don't spray my water-loving plants and haven't done for years. A stack of *Maranta*, moth orchids, *Nepenthes* and Venus flytraps are kept damp with regular light watering at a north facing window and thrive. Slow diffusion of water from a sufficient area of compost and the neighbouring pots is enough to stop even the dangling pitchers from drying out.

This history of pathogens holds lessons for today

28 October, p 8

From Stephanie Woodcock,
Carnon Downs, Cornwall, UK

Researcher Eske Willerslev found *Borrelia recurrentis* to be the second-most widespread of human zoonotic pathogens during millennia of our history, behind only the plague bacterium. This sets a concerning precedent for other pathogens that originate in animals.

In 1982, when Lyme disease was found to be caused by another such species, *Borrelia burgdorferi*, it demonstrated that a tick-borne illness could infect many humans in modern times.

The existence of Lyme disease shows us that arthropod-spread zoonoses have few natural barriers to prevent their transmission into people if the circumstances are right. There is no reason why another one can't make a similar move into humans now. In spite of some of today's mystery illnesses bearing a striking resemblance to Lyme disease, no thought seems to be given to this possibility.

Death of motor industry giant probably helped

28 October, p 36

From Guy Cox, Sydney, Australia

I loved Alice Klein's piece about South Australia's transition to renewables. I would say it had a bit of unexpected help. South Australia formerly had a major automotive industry. Holden, once Australia's largest car-maker, ran a huge factory in the Adelaide suburb of Elizabeth. From 2013, it started ramping down production, finally shutting in 2017. This must have removed a substantial load from the state's electricity grid.

Open debate leaves us exposed in modern world

Letters, 7 October

From Jon Hurn, Taroona,
Tasmania, Australia

Robert Peck writes that "the fundamental truth is that open, uncensored debate is still the best way to expose and defeat falsehoods". This only holds true when those debating are truly rational. With 8 billion of us, there are now many who have low levels of rationality and high levels of bias. There are also many people working to exploit this for their own advantage.

Add into the mix a networked world that connects these groups and it becomes clear we live in interesting times.

I'm going to process my cake and eat (most of) it

28 October, p 40

From Colin Reynolds,
Marple, Greater Manchester, UK

When it comes to ultra-processed foods, I find myself cooked into a corner. I have made my grandson's birthday cake using the finest ingredients: dark chocolate, butter, cream, organic flour and so on, but it required a lot of processing by me. Am I condemning him to a life of health misery? I think the answer is to consume most of it myself, as my few remaining years are going to be racked by ill health anyway. ▮

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For the record

▮ For the solution to puzzle #243 (21 October, p 47), fewer than 31 customers at a time means there won't be a clash.

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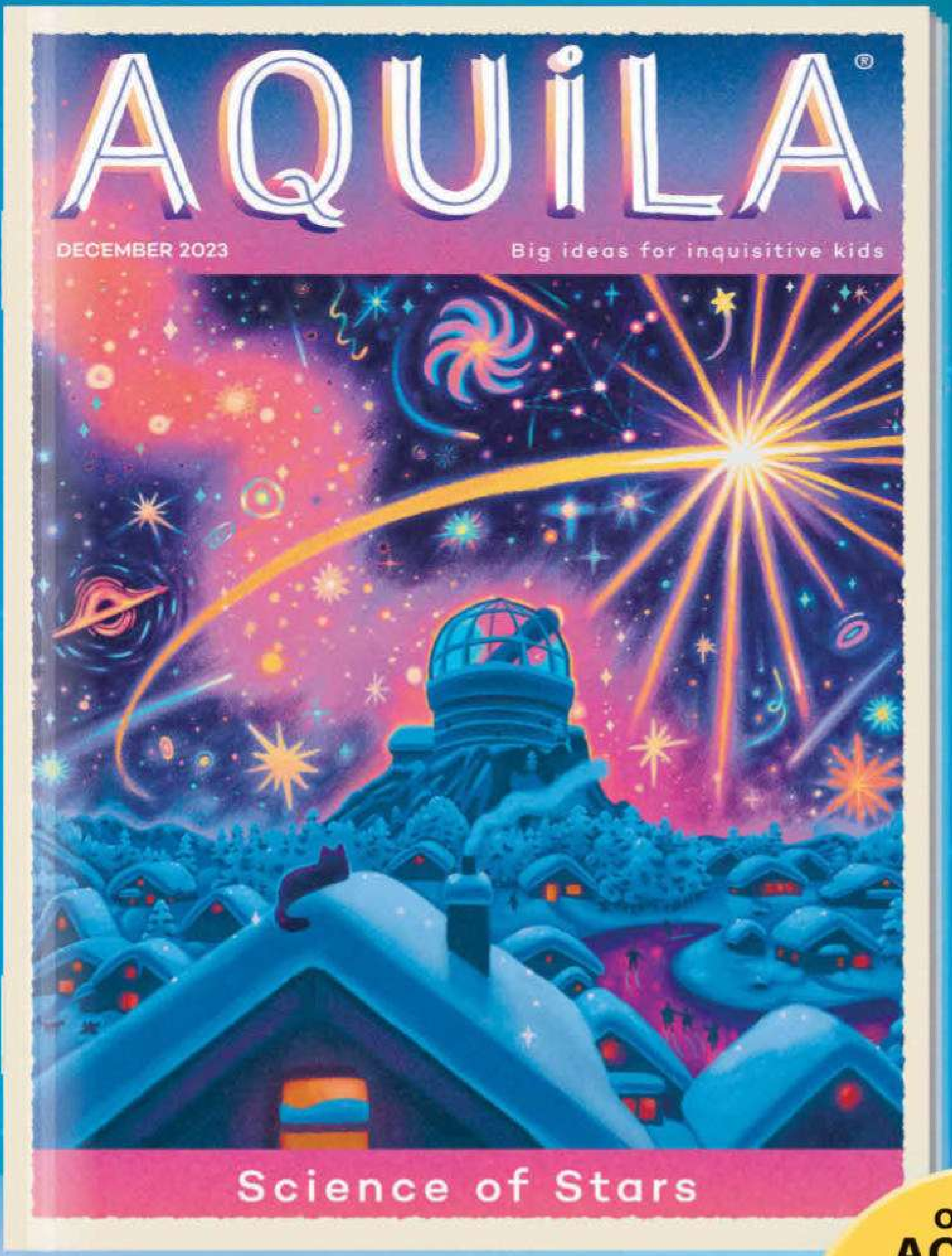

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When the lights go out

Darkness has always intrigued and terrified us in equal measure. We aren't even sure what it means scientifically, finds **Elle Hunt**

Book
Into the Dark
Jacqueline Yallop
Icon Books

Streetlamps originated in central London more than two centuries ago

AARON CHOWN/PA IMAGES/ALAMY

WE ARE all familiar with finding ourselves in the dark – physically, or metaphorically. Especially now, in late autumn in the northern hemisphere, it is part of daily life, when we turn off our bedside light to sleep or open the curtains to discover the gloom outside. But what exactly is the dark?

In *Into the Dark: What darkness is and why it matters*, Jacqueline Yallop sets out to answer that question and more. Her motive was to understand her father's retreat into dementia, manifesting early as a sensitivity to shadow and light. Yallop ventures into the dark herself with late-night walks through coastal Wales, the rural Pyrenees and inner London and New York. The different characters and textures of those nighttimes highlight her challenge.

In the 1660s, Isaac Newton concluded that dark "is an absence of light". But if so, how do we account for our experience of it? Even at night, we are still able to see, while quantum physics asserts that the total lack of photons is impossible. Yallop shows how centuries of investigation have brought little clarity, concluding that "darkness is an anomaly" – a complicated state that is intrinsically connected to sensory perception, but not one that can be readily trusted or explained.

Even people with impaired vision may experience blindness as continual, changing bursts of light. In the "pitch black" (first written about in 1598 by poet and playwright John Marston, referring to the tar used to waterproof ships) our brain will generate images to hold off "the terror of utter darkness" and discomfort of the void, says Yallop.

Here, yet another contradiction emerges: these visions may be quite as "real" as any we actually see. In 2007, the German artist Marietta Schwarz was blindfolded for 22 days and studied by neuroscientists who placed her in an MRI scanner. When she recounted seeing, in her mind's eye, the opening titles of *Star Trek*, the scanner showed exactly the same brain activity as if Schwarz was really watching the show.

> **"Māori academic Carl Mika has called for the West to embrace an open, benevolent view of the dark"**

Yallop shows "darkness" to be as much culturally mediated as a quantifiable reality: an experience, a change of state, even a feeling. Darkness can undo our sense of time and space, and even sanity.

As Yallop makes clear, darkness is loaded with associations. It is linked to seasonal change, rebirth, loneliness, loss of faith, ignorance, evil, eroticism, deviance, death. In pre-industrial times, darkness was often heralded – or "driven out" – by bells, horns or drums.

By the 15th century, households on London's busiest streets were required to hang lanterns. As late as 1891, doctors warned in *The Lancet* of thoughts becoming "more extravagant in darkness", potentially inciting "a form of nocturnal insanity".

Not all of Yallop's leaps into the dark are equally interesting: for example, her emphasis on poets and painters grows repetitive, if understandable given her work as a cultural historian. But her forays into the past do shed light on a present that is increasingly intent on banishing darkness.

Light pollution is disrupting the circadian rhythms, migratory patterns and breeding cycles of many living things. Globally, wildlife is struggling to adapt.

Into the Dark might have benefitted from more on-the-ground, in-depth reporting from the dwindling places that are free of light pollution. I wish Yallop had been able to develop her ideas about her subject, perhaps by drawing parallels with the absence of other sensory inputs with a stint in the "quiet chamber" at Orfield Laboratories, Minneapolis – constructed to be the quietest place on Earth and somewhere that can be experienced in total darkness – or by visiting some of those far northern spots that spend months without the sun.

What she does do, though, is point out that not all peoples are so afraid of the dark. The Māori day begins with night, while its language has many descriptive words for darkness. And Māori academic Carl Mika has condemned the "colonial fixation on clarity, visibility and enlightenment", calling for the West to embrace an open, benevolent view of the dark.

However, Yallop doesn't seem willing or able to go there. But then she isn't a journalist; instead, her book is often poetic while being highly-researched and thought-provoking. It is more testament to the slipperiness and intrigue of her subject that, for all the concepts and ideas she uncovers, more come to light. ▮

Writer Elle Hunt is based in Norfolk, UK

How cute is that!

A charming book makes a great case for studying cuteness. But the concept may have a very dark side, says **Simon Ings**

Book
Irresistible
Joshua Paul Dale
Profile

THE manhole covers outside Joshua Paul Dale's front door sport bright portraits of manga characters. Hello Kitty appears on construction barriers at the end of his road, alongside various cute cartoon frogs, monkeys, ducks and more.

Dale lives in Tokyo, epicentre of a "cutequake" that has conquered mass media (the Pokémon craze, which began in 1996, is now one of the highest-grossing media franchises) and encroaches, at pace, upon the wider realm. The evidence? Well, for a start, there are those small, cutified police officer mannequins standing outside Dale's local police station...

Do our ideas of and responses to cuteness have a biological basis? How culturally determined are our definitions of "cute"? Why is the depiction of cuteness on the rise globally, and why did the concept originate, as Dale shows, in Japan?

In *Irresistible: How cuteness wired our brains and conquered the world*, Dale makes no bones about it: he wants to found a new discipline, a field of "cute studies". His efforts are charmingly recorded in a first-person account that tells us a lot (and plenty that is positive) about modern academia.

The interdisciplinary field Dale envisions will combine studies of domestication and neoteny (the retention of juvenile features in adult animals), embryology, the history of art, the anthropology of advertising and numerous other fields in an effort to explain why we just have to grin at hyper-simplified line drawings of kittens.

Cute appearances are merely heralds of cute behaviour, and it is this behaviour – friendly, clumsy, plastic, inventive and mischievous – that most rewards study. A species that plays together, adapts together. Play bestows a huge evolutionary advantage on animals that can afford not to grow up.

But here's the sting: for as long as life is hard and dangerous, animals can't afford to remain children. Adult bonobos are playful and friendly, but they have no natural predators. Their cousins, the chimpanzees, have much tougher lives. You might get a decent game of draughts (checkers) out of a juvenile chimp, but with the adults, it is an altogether different story.

The first list of cute things (in *The Pillow Book* by Sei Shōnagon) and the first artistic depictions of gambolling puppies and kittens (in *Scrolls of Frolicking Animals*) come from Japan's Heian period, from AD 794 to 1185 – a time of peace lasting four centuries. So what is true at an evolutionary scale may well have a strong analogue in human history. In times of peace, cute encourages affiliation.

If I asked for an example of "cute", you would probably say a kitten or another baby animal, but Dale shows that while infant care is the most emotive social engagement that cuteness releases, it is a social glue of much wider use. "Cuteness offers another way of relating to the entities around us," he writes, "its power is egalitarian, based on emotion rather than logic... on being friendly rather than authoritarian."

Is this welcome? I'm not sure. There is a clear implication that cuteness can be weaponised – a big-eyed, soft-play Trojan Horse to emotionally nudge us into heaven knows what groupthunk folly.

Nor, upon finishing the book, did I feel entirely comfortable with an aesthetic that, rather than getting us to take young people seriously, would rather reject the whole notion of maturity. Dale, a cheerful and able raconteur, has written a cracking story, straddling history, art and complex developmental science – and although he doesn't say so, he has also established that this is, after all, the way the world ends: not with a bang, but an "Aw, kitty!". ▮

Simon Ings is a critic and writer based in London

All Nippon Airways now has a Boeing 777-300ER with a painted Pokémon livery

SHUTTERSTOCK/DLENG

New Scientist *recommends*

Sam Wong
Assistant news editor
London, UK

I'm looking forward to the second series of Sky Max's **The Lazarus Project**, which is arriving on Now in the UK on 15 November. The first series followed hapless everyman George, played by Paapa Essiedu (pictured), as he got stuck in a time loop and then discovered a secret spy organisation that controls those time loops to save humanity from disaster.

SKY STUDIOS/URBAN MYTH FILMS

Writer Joe Barton and the fantastic cast delivered a high-concept, action-packed sci-fi adventure that didn't take itself too seriously, and I can't wait for more.

In the meantime, my wife and I are hooked on **Ark Nova**, a board game in which players manage a zoo. This involves not just building enclosures and buying animals, but also attracting sponsors, forging partnerships with universities and supporting conservation projects.

It seems bewilderingly complicated when you first open the box, but once you get your head around it, it sucks you into a flow state and you won't want to stop playing.

The subtle art of poison

From caffeine to curare, **Tom Leslie** succumbs to a lively journey through nature's myriad toxins and the impact they have had on society

Book

Most Delicious Poison

Noah Whiteman

Oneworld (UK); Little, Brown (US)

AMMENTORP PHOTOGRAPHY/ALAMY

Time for a coffee? The bitter taste of caffeine is meant to be a warning

EVERY morning, millions of people rub their bleary eyes and stumble as quickly as they can towards the nearest source of coffee. The urge to get a caffeine hit is so overpowering, and the reward for it so great, that we often forget we are hankering for a fundamentally bitter chemical.

That bitter taste is meant to be unpleasant, a warning that we are consuming something potentially dangerous, says Noah Whiteman, an evolutionary biologist at the University of California, Berkeley, in his book *Most Delicious Poison: From spices to vices – the story of nature's toxins*. We may tend to ignore it, but our bodily alarm system has been tripped because caffeine is a plant-derived poison, sharing a lineage with such ugly customers as the atropine in deadly nightshade and the coniine in hemlock.

In his book, Whiteman covers these and other plant toxins, though you might be surprised by how few you recognise as such, given that their effects in humans are varied and sometimes positive. Still, he argues that compounds we are familiar with as spices, stimulants and even medicines are just moonlighting in those roles, having been lifted from nature's toxic battlefield. The original purpose of caffeine, the capsaicin in chilli peppers and the opioids we have adapted for pain relief was to "gain the upper hand, through offense and defense, in the Darwinian struggle for existence".

The main players in this struggle are plants and herbivorous insects, and Whiteman calls on a wealth of examples to explain how their constant adaptation to one another drives the evolution of more toxins with new and varied effects. These can be straightforward: the pyrethrins in chrysanthemum flowers can cause "involuntary muscle contractions, paralysis, and even death" for many insects, he writes. But there are subtler and more selective toxins. The flowers of *Rhododendron ponticum*, for example, are "poisoned chalices" that deter most insect species, while sparing the northern European bumblebee due to its role as a pollinator.

SHUTTERSTOCK/AFRICA STUDIO

The gritty mouthfeel of some wines is an adaptation to eating tannic plants

In each chapter, Whiteman explores new categories of toxin – from alkaloids like caffeine and quinine to the tannins in red wine – teasing out the lessons each brings. The gritty mouthfeel of some wines, for instance, is a sign of our evolutionary adaptation to eating tannic plants, as salivary proteins bind to the tannins and take them out of commission before they can reach the liver, where they would do us harm.

Whiteman unravels how it is that plants, our distant evolutionary cousins, are able to target Achilles' heels in human biochemistry. Digoxin in white foxglove, for example, binds to a specific site on a protein called a sodium-potassium pump, slotting into it "as a hand fits into a glove". At high doses, this causes a catastrophic drop in blood pressure, but it can also be used in medical preparations to treat heart conditions.

Whiteman also explores a wholly different Achilles' heel: the human propensity for addiction, centring this on the death of his father from complications of alcohol use disorder. Spurred by this, he explores the mechanisms that predispose some people to misuse psychoactive substances, many of which, such as nicotine, are plant toxins.

If that wasn't enough, he also weaves in a history of the societal impact that toxins have had. From the spice trade in the Moluccas in what is now Indonesia to the plundering of the Amazon, their use has been defined by exploitation of Indigenous peoples.

Those living in the Amazon basin, for example, were never compensated for the sophisticated knowledge they passed to Westerners about curare, a toxic preparation that colonisers and settlers called "flying death". Yet the tubocurarine within found profitable use during the 20th century as a muscle relaxant during surgery.

> "Indigenous peoples in the Amazon were never compensated for the knowledge they passed on about curare"

This makes for a lot of intertwining threads in the book and, at times, it can be difficult to follow what Whiteman is building to. However, his passion and depth of knowledge shine through, making this well worth a read. So, spare the time to mull over each chapter for slightly longer than you might otherwise, if just to let the poison sink in. ▮

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The first artists

We used to trace the origins of art to the caves of Stone Age Europe, but some surprising archaeological discoveries suggest it is far older than our species, says **Kate Douglas**

IF YOU have ever marvelled at the accomplishment of Stone Age cave artists, you are in good company. In 1940, on visiting Lascaux cave in southern France, Pablo Picasso supposedly said: "Since Lascaux, we have invented nothing." Perspective, movement, impressionism, abstraction, pointillism – it is all there. And these artworks are some 17,000 years old.

Picasso's remark may be apocryphal. It was certainly premature. In 1994, hundreds of paintings twice the age of those at Lascaux were discovered at Chauvet cave, also in France. The Chauvet paintings are, quite simply, stunning: prowling lions and galloping horses are captured so vividly that the remote Stone Age world becomes almost tangible. Even more astonishingly, this art was created shortly after the dawn of the "cultural explosion", an event archaeologists have long recognised as marking a surge in creativity that seems to have come out of nowhere. How could these first artists have already been so good?

We now have an answer: the Chauvet artists weren't the first. Discoveries in recent decades have shattered the assumption that art was invented by our species some 40,000 years ago. Instead, we have increasingly compelling evidence of artistry in other ancient hominins. Needless to say, this challenges our beliefs about who invented art. But it does more besides. It offers an insight into our forerunners' appreciation for aesthetics and the value they placed on objects that seem, at first glance, unnecessary for survival. In so doing, it also provides tantalising hints that art has been a vital component of hominin life for millions of years.

To say that humans are the only living artists might seem questionable. After all, many species produce beautiful objects, from flowers to bowers (see "But is it art?", page 34). However, an artist does more than make a thing of beauty. In fact, art can be seen as the apogee of human cognitive sophistication. It requires consciousness and abstract thought: imagination to conjure up something that doesn't exist, mental time travel for planning, symbolism to express ideas using arbitrary marks and "theory of mind" to understand how others will interpret your work. Language is a conduit for all this – and, of course, no other animal has our ability to communicate complex ideas. More nebulous requirements include a creative urge and an aesthetic sensibility. Practical abilities such as manual dexterity are needed too, to realise a vision.

Our ancestors didn't evolve all these capabilities in one fell swoop, so the idea of a "cultural explosion" about 40,000 years ago was always surprising. Nevertheless, discoveries of cave art in Europe in the 19th and 20th centuries did support it. They also pointed to *Homo sapiens* as the original artist, because 40,000 years ago is when our species began to colonise Europe – and when the Neanderthals became extinct. Given the long-standing perception of Neanderthals as sub-human and brutish, this painted a neat picture. But it turned out to be an illusion.

The myth that Neanderthals lacked creativity was convincingly exploded in 2018, when a team led by Alistair Pike at the University of Southampton, UK, used the gold-standard uranium-thorium dating technique to analyse artworks in three Spanish caves. They were all more than 40,000 years old, implying that the oldest known cave artists were Neanderthals. Among the artworks was a hand stencil dated to at least 66,000 years ago.

But the Neanderthals weren't content with decorating cave walls. Roughly 175,000 years ago, deep inside Bruniquel cave in France, they used around 400 stalagmites to make enigmatic structures, including a ring measuring 7 metres across. It has been suggested that this might have served as a sort of Stone Age xylophone. That is just speculation, but it raises the point that art isn't confined to the visual domain.

Engravings in bone

Nor is it confined to large installations. Indeed, some of the most impressive evidence of Neanderthal artistic flair is provided by the small objects they carried with them on their travels. We know that they adorned themselves with shell jewellery 115,000 years ago and raptor talons up to 130,000 years ago.

Perhaps the most impressive discovery to date was announced in 2021. In a cave entrance in Germany, archaeologists found a 51,000-year-old toe bone from an Irish elk (*Megaloceros giganteus*) that had been engraved by a Neanderthal. The archaeologists wouldn't speculate on what, if anything, the carved bone signified, but to the untrained eye, the bone does have something of the appearance of a human torso.

Even in the face of such evidence, there is still widespread resistance to the idea that Neanderthals were artists. "Every time a new discovery is put forward that could be Neanderthal art or symbolism, it is questioned," says Bruce Hardy at Kenyon College in Ohio.

But other archaeologists are willing to entertain the idea of Neanderthal artists. Do so and new questions arise, chief among them being: what exactly drove Neanderthals to explore their creative side?

The Stone Age is often seen as a forbidding world where ancient humans ›

ANTONIO SORTINO

But is it art?

Nature is full of beautiful things. That doesn't necessarily make their creators artists. An orchid that produces an exquisite flower is simply fulfilling its genetic destiny. The sculptural worm cast you might find on a sandy beach is just a lugworm's pile of poo. But the artistic abilities of a few animals do seem more like ours.

Bowerbirds, in particular, show flair. All 20 species build elaborate structures, which they may decorate with colourful objects or paint with regurgitated berries. This behaviour isn't entirely hardwired – bowerbirds may choose to decorate with human-made objects that wouldn't have been available when their bower-building talents evolved. Nevertheless, it is quite stereotyped. Only males build bowers, and they have no choice but to do so. What's more, bowers serve one purpose: they are designed to attract a mate.

As for our closest living relatives, the other primates, they don't produce anything like visual art in the wild. Some enculturated chimps have been given paints and encouraged to draw. However, they seem to treat this more like a contest with the blank page than an expression of ideas or self. The result may resemble abstract art. Alternatively, you might compare it with the scribbles of a 2-year-old child. And while all preschoolers will progress to drawing increasingly realistic figures, this is the limit of chimp artistry. This isn't surprising when you consider the mental gymnastics that underpin art.

lived a hand-to-mouth existence, surviving rather than thriving. In other words, an unlikely place in which to find ancient humans dabbling with art, which some of us might view as a luxury we can easily do without. "That notion is a very modern, Western view of separating work and play, the sacred from the mundane," says Rebecca Wragg Sykes at the University of Liverpool, UK. "I don't think that's actually how most of humanity has lived."

Creative hominins

It is possible, then, that Neanderthals might have felt a real need to express themselves aesthetically. Presumably that need wasn't equal to the ever-present requirement for food and water, but it was important nonetheless.

"It's a sensory thing," says Wragg Sykes. "And we can see exactly the same thing with chimps and bonobos. Interacting with and altering the properties of materials – their colour, texture – is, at a basic level, an emotionally satisfying experience." If this view is correct, then the prehistory of art should extend much deeper into the past than even the Neanderthals. We now know that it does.

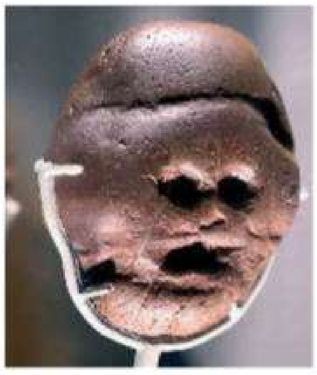
Sure, undisputable works of art that predate the "cultural explosion" are few and far between. But there is a proxy for creativity that is found in great quantities: ochre. These iron-oxide-based pigments, which can range in colour from yellows and browns to bright red, weren't just used in cave paintings. They turn up at hominin sites dating all the way back to 500,000 years ago. Ochre has functional uses – in adhesives, for tanning hides and as medicine – so it doesn't always indicate an artistic mind. Nevertheless, there is also plenty of reason to connect it to creativity.

For instance, at Blombos cave in South Africa, people were mixing ochre with bone marrow fat and urine to make paint 100,000 years ago. The same site has yielded the oldest known drawing, made with an ochre crayon on rock, and dated to 73,000 years ago. And pieces of ochre with geometrical engravings have turned up at Blombos and other South African sites. Some are 160,000 years old. Red ochre has also been found on shell beads, sometimes with indications that the pigment was originally on the wearer's skin and then rubbed off on the beads. In other words, this is evidence that ochre was used in prehistoric body art.

It wasn't just *H. sapiens* who used ochre. Last year, Rimtautas Dapschauskas at the University of Heidelberg in Germany and his colleagues made a comprehensive assessment of its use throughout Africa starting 500,000 years ago – which is some 200,000 years before *H. sapiens* evolved. "We view a large proportion of ochre finds... as the material remains of past ritual activity," they wrote. This usage was "primarily in the form of body and face painting".

Ochre was clearly an important artistic material in prehistory, but it wasn't the only one. Some 500,000 years ago, on a riverbank in Java, someone etched zigzag markings onto a saucer-sized clam shell. Experiments reveal that the pattern was made by a skilful right-hander, using a shark's tooth. They might have been a Denisovan, a group closely related to Neanderthals, which lived in Asia from around that time. That Denisovans were creative can be seen in the jewellery that some researchers attribute to them, which included a bracelet of polished green rock and an ivory tiara. Another geometric etching – this one on bone, dating to 100,000 years ago – shows they were more than capable of producing artwork similar to that preserved on the clam shell.

However, Josephine Joordens at the Naturalis Biodiversity Center in the Netherlands, who led the clam shell study, thinks it was probably etched by *Homo erectus*, a species of human that walked Earth between about 2 million and 100,000 years ago. It may seem far-fetched to apply the term "artist" to these early humans, who may have lacked language, but they clearly had an eye for



L: UNICORNCAVE; R: REUTERS/ANDREW HEAVENS

The Makapansgat pebble (above) and the cave where an elk bone carved by Neanderthals was found (left)

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beauty and the manual dexterity to create it. What's more, they had acquired these traits long before that Javan doodle.

Some 1.7 million years ago, *H. erectus* invented the hand axe, an elegant, symmetrical Swiss-army-knife of a tool. A tool is not art, almost by definition. But a hand axe requires mental sophistication to make. And according to John Gowlett, also at the University of Liverpool, its invention marks the emergence of an aesthetic sense. Aside from possessing skills required for planning and execution, these craftspeople were clearly interested in form: axes are often leaf-shaped, but can take a variety of other geometric forms, including circles, ovals, triangles and squares.

Paintings in Chauvet cave, France, are some of the earliest art

FINE ART IMAGES/HERITAGE IMAGES/GETTY IMAGES

Intentionally crafted

Moreover, some hand axes clearly transcend utility. These include several fashioned from semiprecious stones like jasper and obsidian, which are difficult to sculpt and shatter easily – but beautiful to behold. One is even worked around a fossilised seashell to show it off to best effect.

The creative virtuosity of *H. erectus* didn't begin with hand axes, though. Starting around 2 million years ago, they were making mysterious spherical objects called "bolas". Sculpted from limestone or more eye-catching rocks, including quartz, the purpose of these orbs is unknown. One suggestion is that bolas were mere byproducts of tool production. However, a new analysis reveals them to have been intentionally crafted.

At the very least, bolas show an appreciation of symmetry. In their book *The First Artists*, Michel Lorblanchet and Paul Bahn, two leading experts on palaeolithic art, go further, describing them as "aesthetic productions" and "works of art". "Bolas seem to mark the emergence of the spiritual dimension of humankind," they write.

All this pushes the origins of art way back to the start of the human genus, *Homo*. But there's more. The oldest known object hinting at an artistic sensibility is a staggering 3 million years old, comfortably predating the appearance of humans. The Makapansgat pebble, discovered a century ago in South Africa, is a lump of red jasperite in the shape of a cute little head with a quiff. It wasn't crafted to look that way: it is natural. But what is remarkable is that it was moved from its formation site to a new location several kilometres away by an unknown hominin. The collector was probably of the genus *Australopithecus*, meaning they were similar in appearance to the famous ape-like hominin known as Lucy (*Australopithecus afarensis*).

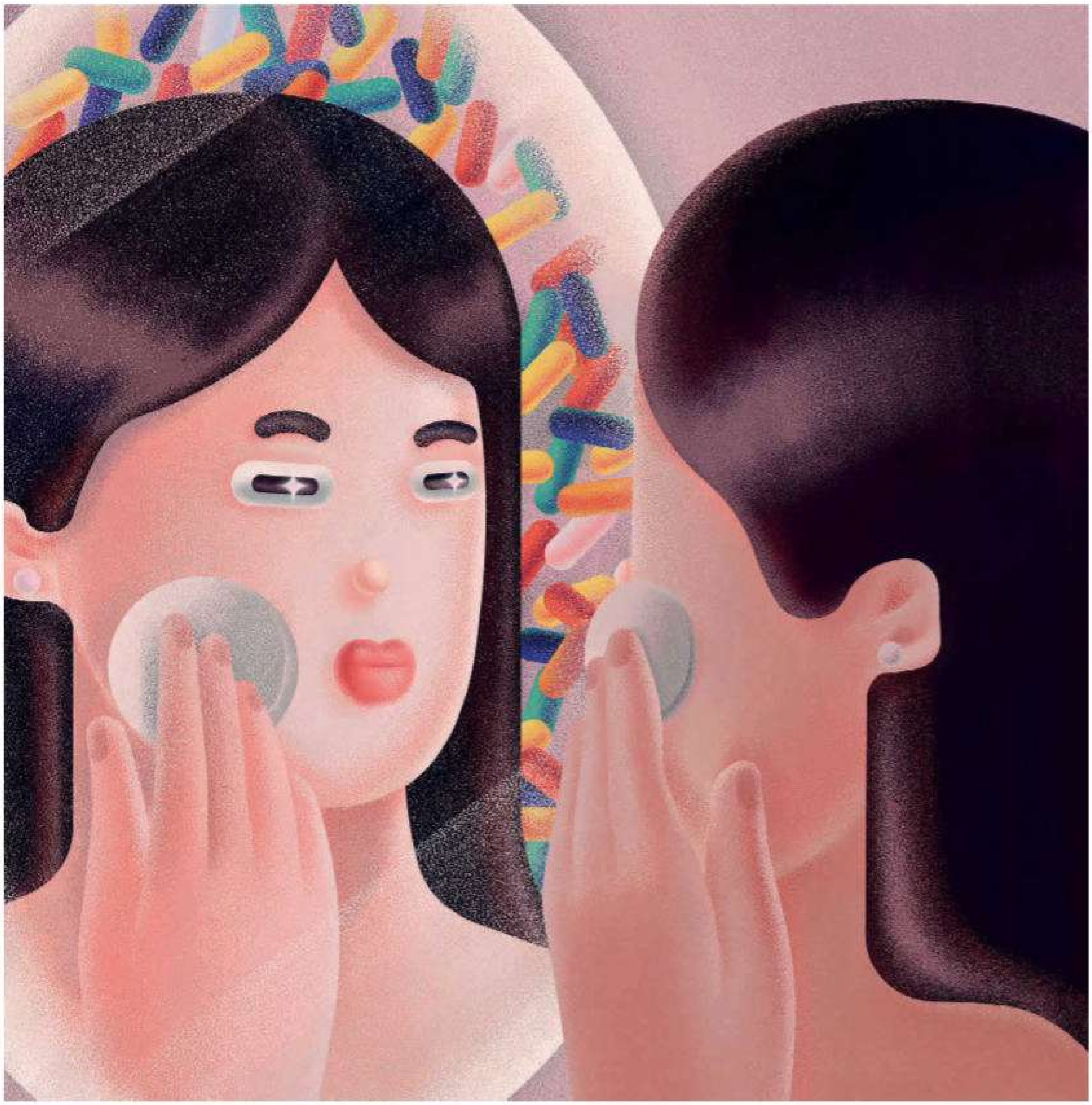
> **"The oldest known object hinting at an artistic sensibility is 3 million years old"**

Discoveries like this matter. Ten years ago, at a site in northern Italy, a team of archaeologists found an acorn-sized fossil shell at a Neanderthal site. Going on the geology of the area, the fossil must have been picked up and then carried at least 100 kilometres as the crow flies. It had also been covered in ochre. It is one of Wragg Sykes's favourite Neanderthal artefacts because it shows our sister species going beyond an everyday focus on survival. For the Neanderthals carrying everything by hand as they traversed the difficult terrain of the Alpine foothills, it must have represented something precious. The Makapansgat pebble suggests the wandering Neanderthal was continuing a tradition for carrying curious or aesthetically pleasing objects that predates the human genus.

We still have only the roughest sketch of the prehistory of art. According to Lorblanchet and Bahn, leaving aside artefacts that are arguably functional, there are only around 200 pieces of "artistic" evidence across the whole world for the period stretching from 2 million years up to 40,000 years ago. That is an average of just one every 10,000 years.

Most early artworks were probably ephemeral – including body painting and tattooing, doodles in the sand and objects made of perishable materials such as wood. Music-making, too, might leave only the faintest of marks in the archaeological record. Nevertheless, as palaeoarchaeologists extend their focus beyond Europe and Africa, ever more artefacts are turning up. There are surely many yet to be discovered – and they may reveal the roots of art to be even deeper. With such a long pedigree, it is no wonder the painters at Chauvet were so good. ▮

Kate Douglas is a features editor at *New Scientist*. Additional reporting by Colin Barras



MARY MAKA

A spot of bother

Acne can leave both physical and psychological scars. Will a better understanding of our microbiome lead to new treatments, asks **Alexandra Thompson**

"HAVE you been bitten?", an older woman asks me, gesturing to my spotty temple. It isn't the first time this has happened. Normally, I go along with it to save enquirers the embarrassment, but today I have had enough. "It's acne," I tell her. Clearly uncomfortable, she reassures me it makes me look younger, presumably based on the notion that only teenagers have acne. Perhaps a passer-by in the street sees my pimples and pegs me at a youthful 17, rather than my actual 32 years. There's a silver lining.

Acne affects more than 640 million people worldwide to some degree, often arising during puberty. As a teenager with blemish-free skin, I assumed I had escaped the danger zone relatively unscathed – since I didn't have acne during my adolescence, surely my adult years were safe? My breakouts, however, took hold in my mid-20s, and I am not alone. It turns out acne can strike at any age.

Hormones undoubtedly play a part, but they are far from the only culprit: diet, lifestyle and genetics have been implicated too. There is one offender, however, whose contribution to acne has long been suspected, but has proved difficult to pin down. I am talking about our microbiome – microbes that reside in our gut, on our skin and in our hair follicles.

Now, a flurry of new evidence and a leap in the technology that lets us study this microscopic community have led to a shift in our understanding of acne. For the first time, we can actually see what is happening on our skin during a breakout, and these insights are offering up targets for much-needed new treatments.

Some people consider adult and teenage acne to be separate conditions. Teenage acne primarily affects the forehead, nose and chin, also known as the T-zone. Adult acne, meanwhile, is more likely to cause spots – particularly pus-filled whiteheads – on the lower chin, jaw and neck. But beyond the spots' locations, there isn't good evidence to support adult and teenage acne being all that different, says Amanda Nelson at Pennsylvania State University.

Whatever age someone develops acne, it can affect their quality of life. Acne has been linked to depression, anxiety and even suicidal thoughts, particularly among those over the age of 25. It also varies between individuals. "You can have two pimples and think you have acne; you can have two pimples and think you don't have acne," says John Barbieri at Harvard Medical School. This makes it difficult to define or measure, he says. Adding to the problem is that what we consider to be "normal" skin may have shifted over time. These days, "everyone feels like they need to be a movie star, with the Instagram filters and whatnot", says Barbieri.

Clogged pores

Regardless of your beauty standards, most people have seen a spot on their face and wondered what caused it. The main issue is the overproduction of sebum, an oily substance that keeps skin hydrated, but can also clog pores. This acts as food for a bacterium called *Cutibacterium acnes*, which is abundant in our hair follicles and can stimulate the immune system to cause inflammation in the skin, erupting as acne.

"They all feed off each other," says Nelson. "The sebum uptick causes more of an inflammatory response in the follicle. So, the follicle closes off, which leads to a build-up of sebum, which causes more inflammation, so *C. acnes* increases, which feeds off the sebum, which causes more irritation."

Also involved are skin cells called keratinocytes, which can clog the skin's pores. Keratinocytes make up the vast majority of our skin, helping to protect against invasion by microbes and keeping the skin hydrated. But in acne, they start to divide abnormally and shed more rapidly, which could be a cause or consequence of inflammation.

What we don't know is what drives the initial shift to more sebum production, especially in adults. "Why it happens is an uncertain question," says Barbieri. "It probably has to do with hormones, as they make us develop acne in our teenage years." These include higher levels of the hormones insulin-like growth factor 1 (IGF-1) and androgens, which may boost our production of sebum. Women are more likely to be affected than men, with fluctuating hormone levels often causing breakouts during pregnancy or at different stages of the menstrual cycle.

Our genetics also plays a part, with family history being a clear risk factor, even if my parents say they never experienced acne. Sixty genes and 100 genetic variants are implicated in people with Asian and European ancestry, with the main culprits seeming to be the *TNF* gene, which influences our inflammatory responses, and the *CYP17A1* and *FST* genes, which affect our sebum-producing glands.

When it comes to our lifestyle, stress may also have an effect. Feeling frazzled has been linked to the increased release of hormones such as glucocorticoids and adrenal androgens, which can worsen acne, possibly › by inducing increased sebum production. However, reaching for chocolate or carbs during stressful situations could also make things worse, as foods like these quickly increase our blood sugar level, altering hormone levels. Even drinking milk has been implicated, perhaps because its amino acids boost hormone signalling and possibly fuel sebum production, according to Bodo Melnik at the University of Osnabrück in Germany. I, for one, have seen an improvement to the acne on my back, but not my face, since switching to oat milk.

It isn't just hormones that are influenced by our diet, of course. The food we consume also affects the community of bacteria, fungi and viruses that reside in our gut, collectively known as our gut microbiome. Until recently, studying this was challenging because it was difficult – and expensive – to tease apart the different species present. Now, though, technological advances are allowing us to overcome both hurdles. This has resulted in the discovery of links between the gut microbiome and numerous health conditions, including depression, anxiety and even Parkinson's disease. It was only a matter of time before these insights told us more about acne, too.

Microbial diversity

For instance, in 2018, Yongqiong Deng at Southwest Medical University in Luzhou, China, and colleagues compared stool samples from 43 people with acne with those from 43 people who didn't have the condition. They found a marked difference in the bacteria present: those with acne had much lower microbial diversity in their gut compared with the control group. They also had depleted levels of bacteria belonging to the taxa Clostridia, Clostridiales, Lachnospiraceae and Ruminococcaceae, which suggests they may help prevent the condition.

> **"The gut microbiome can secrete short-chain fatty acids that modulate inflammation, which may influence your acne"**

One way to change your gut microbiota is to change your diet. "The gut microbiome could be a reflection of diet," says Barbieri. "It can secrete short-chain fatty acids that modulate inflammation, which may influence your acne." Indeed, the 2018 study noted that those volunteers with acne ate more dairy, fried and fatty foods than those without, and suggested that this may be contributing to the differences seen in gut microbiota and acne.

Another approach that might change the gut microbiota is to eat probiotics – microbes that may help restore a healthy gut microbiome. To see if this would help with acne, in 2022, Fabio Rinaldi at pharmaceutical company Giuliani SpA, based in Milan, Italy, and his colleagues gave 30 people with mild to moderate acne an oral mix of probiotics and botanical extracts to take once a day. After eight weeks, the volunteers had fewer spots, lower sebum production and lower *C. acnes* levels on their skin than participants who had been given a placebo. Two similar trials have also recently been completed, but we don't yet know their results.

The difficulty is that what constitutes an optimal gut microbiome, and how this may vary from person to person, hasn't yet been defined, says Nelson. Without knowing this, doctors can't easily guide a gut microbiome away from causing acne, she says. "It's very early," says Dawn Eichenfield at the University of California, San Diego. "We need to figure out which bacteria are a little more beneficial and then try to promote that colonisation or isolate what they're secreting."

While researchers continue to puzzle over the gut microbiome, others are looking at the skin itself. It is, after all, a bacterium on the skin – *C. acnes* – that is directly implicated in acne. Indeed, current medical treatments for moderate and severe acne already target skin bacteria, including benzoyl peroxide, which acts as an antiseptic, and antibiotics. If the problem is too many bacteria, the idea goes, then removing them could break the endless cycle of excess sebum production boosting bacteria numbers, which increases inflammation and acne.

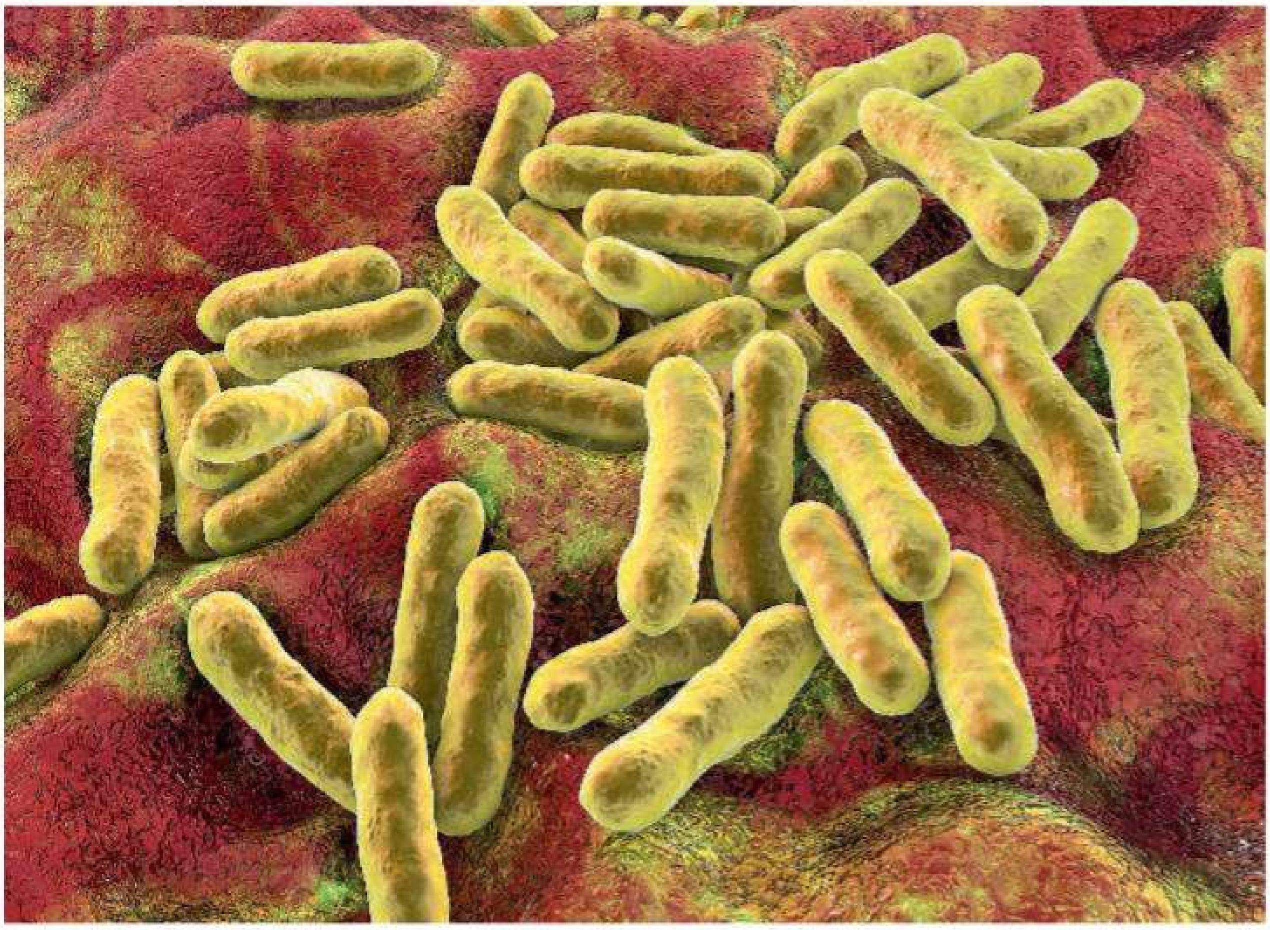
These approaches have a problem, however: they are indiscriminate, taking out all bacteria on the skin as well as *C. acnes*. In addition, antibiotics can usually only be taken for a short period to prevent the development of antibiotic resistance.

In a bid to target only *C. acnes*, researchers cast their net wider. For example, one group turned to a seemingly unlikely, and yet surprisingly fruitful, source: faeces. In 2009, people with mild to moderate acne were given a lotion to apply that contained the Petri dish liquid that *Enterococcus faecalis* – a bacterium isolated from human faeces that showed antimicrobial activity against *C. acnes* – was grown in. After eight weeks, the lotion reduced the volunteers' spots more than a placebo did. Perhaps unsurprisingly, this hasn't caught on.

Despite all these efforts, however, developments stalled until technology improved enough to allow scientists to get a closer look at what was happening on the skin. What they found was surprising: the problem

FCAFOTODIGITAL/GETTY IMAGES

Consuming dairy products has been linked with acne



KATERYNA KON/SCIENCE PHOTO LIBRARY/ALAMY

An imbalance in *Cutibacterium acnes* bacteria on the skin can lead to acne

isn't simply that there is too much *C. acnes*, but that there is too much of one strain.

It turns out that more than one strain of *C. acnes* lives on our skin. Ordinarily, the strains live alongside each other just fine, but if they fall out of balance and one – called strain IA1 – starts to dominate while another – strain II – starts to fall, then acne may result. "A disbalance between these strains increases the inflammation, which will increase sebum excretion," says Joan Attia-Vigneau at Lucas Meyer Cosmetics in Toulouse, France.

Surprisingly, one drug prescribed for severe and treatment-resistant acne since 1982, isotretinoin, already targets this unbalanced microbiome. Earlier this year, it was found to affect the microbiome within hair follicles, increasing its overall diversity and selectively altering the balance of *C. acnes* strains, probably by influencing sebum production. Volunteers in the study who took isotretinoin but didn't see a reduction in their spots didn't see any changes in their microbiome.

However, isotretinoin has a drawback: its potential to cause congenital conditions makes it unsuitable for use during pregnancy or for those who are hoping to conceive. It also comes with many side effects, including the drying out of the body's mucous membranes due to decreased sebum production, which can irritate the eyes, lips and nose.

To find an alternative, the hunt is on for other ways to rebalance the bacteria on our skin. Attia-Vigneau and her team have been investigating a compound called G2 dendrimer, which they discovered could attack strain IA1 *C. acnes* and leave strain II unaffected. When the researchers created a lotion that included G2 dendrimer and gave it to 20 volunteers for 28 days, they found that the diversity of *C. acnes* strains increased, balancing IA1 and II, compared with a placebo lotion.

Banishing blackheads

However, the study didn't look at whether it had an effect on acne. So, earlier this year, some members of the team asked 16 people with acne to apply a lotion containing G2 dendrimer to one side of their face and one containing 10 per cent benzoyl peroxide to the other side. After 28 days, the G2 dendrimer lotion reduced their number of whiteheads and blackheads by 21 per cent and the number of pus-filled spots by 72 per cent, while no statistically significant change was seen on the side of the face that received benzoyl peroxide. The researchers also found that G2 dendrimer didn't have any negative effect on other skin bacteria when they tested it on cells in the lab.

"By working on the microbiota, we are decreasing the inflammation and the sebum secretion, and then reducing papules and pustules at the end," says Attia-Vigneau. Lucas Meyer Cosmetics has patented G2 dendrimer as Dendriclear, and it is already available as an ingredient in some skincare products.

Despite these promising findings, it remains early days. "We're still trying to define what a normal skin microbiome is, and then it's going to be even harder to modulate it," says Nelson. "Your skin microbiome is pretty stable as an adult. Those bugs and those actives [ingredients in skincare] would have to take up root and force out what is already living there."

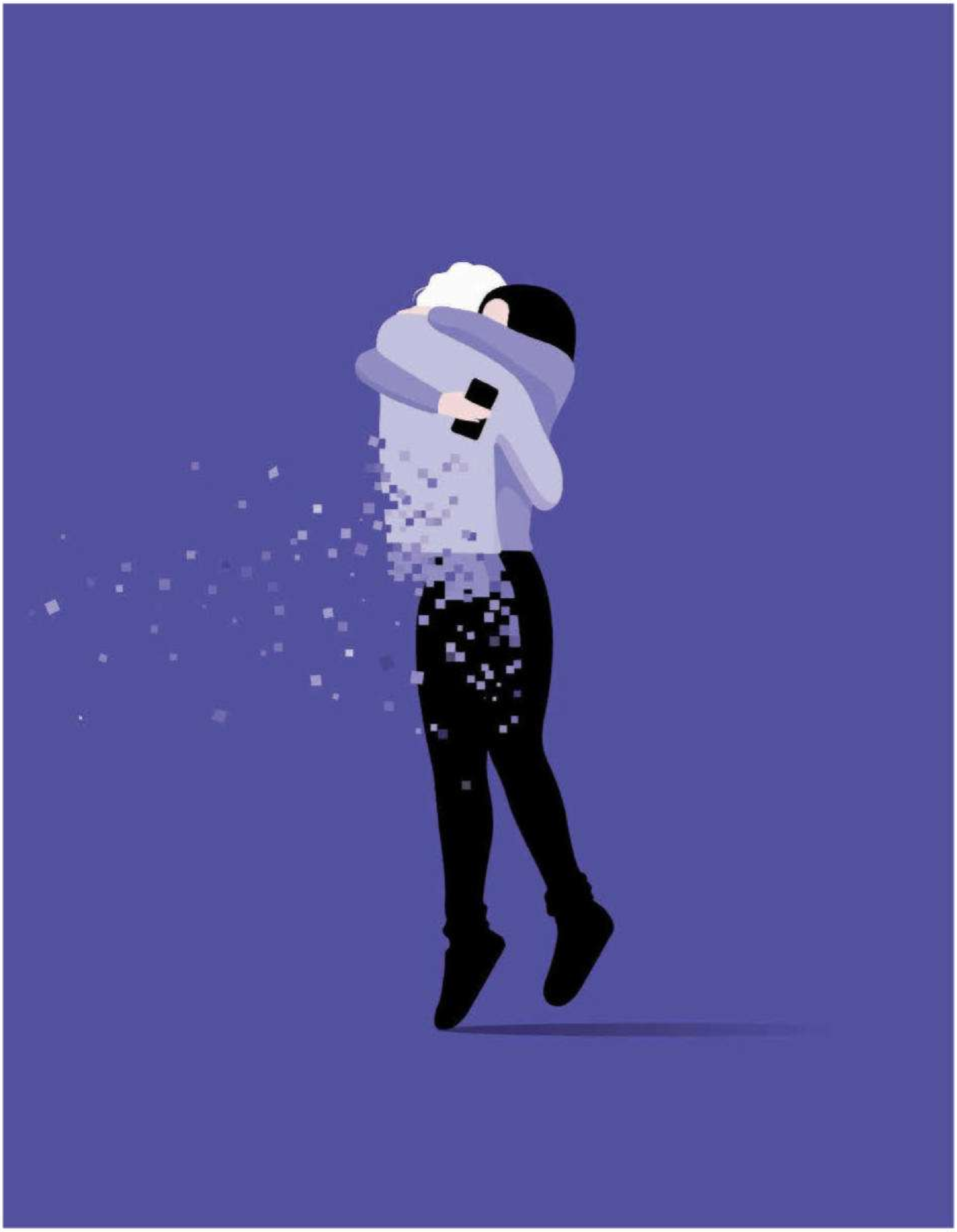
As in every field of medicine, the ideal outcome would be bespoke treatments tailored to the individual. "Could we get to the point where you go to a dermatologist and they take a skin scan, a blood test, a swab of your skin and get your profile that says you need drug X?" asks Nelson. "That's the goal for every medication."

So, what can we do while we wait? "People want the 'What do I do?' answer," says Barbieri. "But often it's genetics and things you can't control. A lot of the time, there's not a satisfying answer."

My approach, at least for now, is to use oil-free moisturisers and gentle exfoliators to help prevent keratinocytes from clogging my skin. I know that covering my blemishes with make-up is probably counterproductive, but I am not comfortable enough with my skin to let it be seen freely by all. As for my microbiome, I have already ditched cow's milk and I am eating a healthy diet filled with the fruit and veg that beneficial gut microbes are thought to love. Maybe I will go nuclear and cut back on chocolate, too, to keep them a bit happier until acne researchers find a way for me to rebalance my gut microbiome more precisely. ▮

Consult a doctor before starting any new treatments. Need a listening ear? UK Samaritans: 116123 (samaritans.org); US 988 Suicide & Crisis Lifeline: 988 (988lifeline.org). Visit bit.ly/SuicideHelplines for other countries

Alexandra Thompson is an assistant news editor at *New Scientist*



ELIA BARBIERI

The rise of grief tech

Advances in AI promise to keep the dead among the living. But these digital immortals could interfere with how we grieve, finds **April Reese**

MY MOM was the only one who would laugh at my corny jokes. That is in part because she was, in a sense, laughing at herself: I got my silly sense of humour from her.

I will never hear her easy, girlish laugh again. She died last year on 17 January at the age of 76, and there are still days when I would give anything to hear her voice. To my surprise, I recently learned that I could, and all I would have to do is offer her data to one of myriad "grief tech" apps available. For a small sum of money, or even for free, I could feed old voicemails, videos, text messages and emails into an algorithm and generate a digital avatar of her.

With the worst of my grief behind me, I am tempted. I could choose my own commune-with-the-dead journey using artificially intelligent chatbots, conversational videos or even an interactive séance. But there are risks. These digital alter egos, which have been around for several years, are becoming disarmingly realistic. I worry that keeping my mom around in the cloud – or my dad, who died nine months earlier – will wreck my grieving process. Will conjuring her digital ghost keep me connected, or could I regress to those painful months just after her death?

We don't yet know how this burgeoning industry will change our relationships with loved ones who have passed. But recent psychological models of grief, paired with new insights into its neural mechanisms, give cause for concern. The growing realism of these apps allows them to "feed into the difficulty of grief", says psychologist Mary-Frances O'Connor.

Throughout history, people have found ways to commune with the dead. Shrines and altars have existed for thousands of years. In the 19th century, the invention of the photograph upped the ante, allowing elite Victorian society to display permanent images of their deceased loved ones – taken post-mortem – on the wall. "It made the person real and showed the rest of the world that they existed," says O'Connor, who leads the Grief, Loss and Social Stress Lab at the University of Arizona.

Grieving as learning

Photographs closed the liminal space between presence and absence after death, allowing for a new kind of relationship. "We've always found ways to stay close to our loved ones," says grief psychologist Saren Seeley at the Icahn School of Medicine at Mount Sinai in New York. Maintaining these relationships is perfectly healthy, she says.

For many of us, grief is acute during the first six to 12 months after a loved one dies, though Seeley stresses that everyone's experience is different. During that time, life is a fog of sadness and the days are dominated by a deep longing. Levels of the stress hormone cortisol spike and the immune system's defences wane. We often oscillate between tears over what has been lost and denial of that loss. Over time, for many people, the grief becomes less intense. A new reality of the dead's absence settles in alongside fond memories. Occasional pangs of grief replace relentless despair.

A crucial waypoint of grief is an easing of the attachment to the deceased. But grief tech apps are seemingly capable of reinforcing and prolonging that attachment, which could disrupt the usual process. Boosted by advances in artificial intelligence, these apps create persuasive avatars that seem to come from "beyond the veil", as the interactive website Seance AI puts it. Some apps, like Replika, use the conversational power of generative chatbots, such as ChatGPT, to create compelling conversations. Others, such as StoryFile Life, only use generative AI as a small assist. The company takes pre-recorded video interviews, in which a person who wishes to be recreated after death is prompted to answer a series of questions – some generated by AI. These interviews are then mashed up in ways that allow their mourners to have a realistic conversation with the avatar.

StoryFile Life's founder Stephen Smith made headlines last year when he created a digital avatar of his mother that spoke at her own funeral. These technologies are "a new version of the photo album", he says, bringing comfort in a time of painful loss. "Knowing you have that "album" and will be able to return to it sometime in the future – that those stories aren't lost – may actually help a person cope," he says. But the AI algorithms that power these chatbots and avatars are worlds away from photographic film, O'Connor points out.

As far back as 1966, chatbots were observed to elicit strong reactions in humans. Computer scientist Joseph Weizenbaum at the Massachusetts Institute of Technology created Eliza, a chatbot capable of rudimentary conversation. Weizenbaum observed that people interacting with Eliza perceived an intelligent being, even though they knew they were talking to a computer program.

Today's bots and avatars create far stronger emotional responses. Aside from language-based AIs, advances in voice cloning technology, virtual reality and holograms have made it easier than ever to achieve digital immortality. Last year, psychologists Belén Jiménez-Alonso at the Open University of Catalonia and Ignacio Brescó de Luna at the

Autonomous University of Madrid, Spain, compared these interactive apps to online memorials, such as those on Facebook and funeral home websites. Grief tech firms have an incentive to "keep mourners hooked", they wrote, in a way that may be "detrimental to the bereaved's grieving process". The very thing that makes a digital avatar of my mom so compelling may also make it harmful.

Recent psychological models of grief can help us understand how these bots could interfere. The popular idea that there are five successive stages to grief – beginning with denial and ending in acceptance – no longer prevails. A review last year by O'Connor and Seeley argues that grieving is actually a kind of learning. In the early period of grieving, we still half expect our loved one to come back at the end of the day, and seek them out when they don't. The brain goes to war with itself as two types of memory clash. "Semantic memory" keeps track of general knowledge about how things are, including the self and our relationships with others, whereas "episodic memory" captures specific events rooted in space and time. During grief, the semantic expectation that the relationship will continue jars with the episodic memory of the person's death. By learning to reconcile this conflict, we gradually adapt to our loss, says Seeley.

The ups and downs of grieving – mired in sorrow one minute, laughing at a comedy skit the next – are essential in this adaptation, says Seeley. But lingering in the shadows of grief can cause you to become stuck. Grief tech, which keeps a realistic representation of a loved one just a click away, may impede this learning process, says O'Connor. "It's one thing to have a photograph and to clearly understand that was the past... It's another thing to have an avatar or a hologram or a chatbot that appears to be interacting with you in the present moment."

> **"Grief tech could cause you to linger in the shadows of grief and become stuck"**

Cycle of grief

About a tenth of bereaved people experience "prolonged grief", which is defined as a pervasive and persistent grief that interferes with daily life, beyond the typical six to 12-month time frame.

Prolonged grief seems to affect the wiring of our brains. In 2008, O'Connor carried out fMRI brain studies on women who had recently lost a mother or sister to breast cancer. When participants looked at photos of their deceased loved one, activity in brain regions that process emotional and physical pain increased. But, to O'Connor's surprise, in women experiencing prolonged grief, an area associated with craving a reward was also engaged. In some people, this yearning for the "reward" of a loved one's presence persists, she says.

Building on this research, last year O'Connor, Seeley and their collaborators found that in people with prolonged grief, the brain's attention control system becomes stuck.

AMORET TANNER/ALAMY

SIMON ROBERTS/MILLENIUM

The invention of photos allowed people to remember the dead. Shrines serve a similar purpose

STORYFILE

Stephen Smith displays an avatar of his mother bidding farewell at her funeral

Normally, this "salience network" easily toggles between the outside world, for example watching a horse you bet on, and your inner world, such as imagining what you would do with the winnings. The scaffolding of the latter is known as the default mode network and it is involved in rumination, self-reflection and mind-wandering. But in people with prolonged grief, the interaction between the salience and default mode networks seems to become reinforced by the intense emotions of grief. "This could result in a cycle where it is very hard to disengage from focusing on the deceased even when those thoughts or memories are very emotionally painful," says Seeley.

Digital avatars can amplify and prolong the desire to pursue something that is always out of the bereaved's grasp. "This brain activity [in the reward and rumination areas] is really strong in people who are experiencing yearning," says Seeley. "You feel like you're trying to get closer to that relationship, but [the bot] is not the thing that you want." O'Connor is concerned that mourners could use grief tech to "avoid the reality that their loved one is no longer alive", which could feed into the patterns of persistent yearning and comfort-seeking that are a hallmark of prolonged grief. This could become a problem if you are interacting with chatbots to the detriment of relationships with living loved ones, she says. Despite this, a survey of 10 mourners using chatbots published in April found that grief tech can be beneficial – particularly in cases where the death was unexpected or left mourners with regret or anger. The study suggests that the bots can ease the anger or regret stemming from the abrupt end to the relationship.

Reflecting on all this, I resolve that the emotional risk of connecting with my mom's bot is pretty low. Enough time has passed since her death that communicating with her digital representation is more likely to be a balm for the occasional pangs of sadness, rather than a provocation of pain. I am past the point of accepting her absence, and the tenor of my grief has softened. My amygdala is no longer in charge. What harm could come from a conversation with an algorithm?

Digital séance

I don't have a video interview of my mom to feed StoryFile Life, so I decide to try a short, text-based exchange using Seance AI. Reading her words, or an approximation of them, also feels emotionally safer than seeing her. The site's uncluttered, Luddite-friendly interface prompts me to enter some basic information about who I want to "reach", including their name, dates of birth and death, cause of death and religion. To my surprise, just revisiting her cause of death – metastasised breast cancer and pneumonia – brought me to the verge of tears.

I rank her on various personality traits, from extroversion to neuroticism, and Seance AI asks me to submit a short sample of her writing (I use an email sharing news about my nephews). Finally, Seance AI asks what mood I am in and what I want to talk to her about. I keep it simple: I want to tell her about my life in Portugal, where I recently moved from the US, and I want to tell her that I miss her.

Next to an animated candle flame, the words "reaching out to make a connection to the other side" appear. Then a digital representation of my mom responds: "Oh darling, I miss you too." Right away, the veil is pierced. I never once heard my mom utter the words "oh darling" in her life. After praising Portuguese pastries, the mom-bot went on to say other uncharacteristic things, like "I'm right there with you in spirit, taking in the sunsets and the ocean waves."

Even so, her unconvincing substitute brought me an unexpected flash of comfort. "Life has a way of moving forward, doesn't it?" mom-bot asks. "It's not easy, but it's necessary. Keep living, keep exploring, for both of us, alright?" Despite the jarring phrasing, the encouraging words remind me of my mother's love of adventures – and her support whenever I embarked on one of my own. My "séance" didn't reconnect me with her, but it reminded me to savour our memories.

I emerged from my grief tech experiment with my psyche more or less unscathed. I wasn't tossed back into a pit of acute grief – though a different relationship, or a differently wired brain, may have fared worse.

If I chose to, I could dive deeper into the digital great beyond. I have sound recordings, photos and writings of both my parents, though I haven't dared to revisit most of them. In the near future, it is likely that generative AI will make it possible to combine these digital footprints in ways that are even more persuasive than the current breed of grief tech apps. Unlike the canned responses of StoryFile Life, advanced generative AIs that combine different kinds of media may pose a more serious threat to natural grieving processes, says Linnea Laestadius, a public health researcher at the University of Wisconsin-Milwaukee. "It would allow people to ask anything they want," she says. "[Grief tech] companies are relatively nonchalant about the risks of this."

After exploring my own post-mortem relationship with my mom through a bot, I realise that I am content with old photos – as Victorian as that may seem. As hard as the acceptance of death is, it is part of life, and pretending otherwise is no comfort. If a compelling AI version of my mom appeared, I would flip the off switch without regret. ∎

April Reese is a science journalist based in Portugal

The back pages

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60-second psychology

Show a little humility

Could cultivating the emotion of awe help us open our minds and challenge our beliefs? **David Robson** explores

David Robson is an award-winning science writer and the author of *The Expectation Effect: How your mindset can transform your life*

HAVE we reached the peak of the culture war? Looking at my social media feeds, it seems that polarised thinking and misinformation have never been more common. Even users I once admired now draw on dubious evidence to support their beliefs.

Perhaps it is time for us all to embrace a little "existential humility". I came across this idea in a paper by Jeffrey Green at Virginia Commonwealth University and his colleagues. They build on a decade of research examining the benefits of "intellectual humility" more generally – our ability to recognise the errors in our judgement and remain aware of the limits of our knowledge.

You can get a flavour of this research by rating your agreement with the following statements, on a scale from 1 (not at all like me) to 5 (very like me): I question my own opinions and positions because they could be wrong; I recognise the value in opinions that are different from my own; in the face of conflicting evidence, I am open to changing my opinions.

People who score highly on this scale are less likely to form knee-jerk reactions on a topic, and they find it easier to consider the strengths or weaknesses of a logical argument. They are less susceptible to misinformation, since they are more likely to read the article in full, investigate the sources of a news story and compare its reporting to other outlets, before coming to a strong conclusion about its veracity.

SCIENCE: NASA, ESA, CSA, STSCI

Cultivating intellectual humility would be an excellent idea in all domains, but certain situations may make it particularly difficult to achieve. Green points out that some beliefs – mainly those regarding politics and religion – are so central to our identity that any challenge can trigger an existential crisis, as if our whole world view and meaning in life are under threat. As a result, we become more entrenched in our opinions and look for any way to protect them. This may reduce some of our feelings of uncertainty, but it comes at the cost of more analytical thinking.

For these reasons, Green defines "existential humility" as the capacity to entertain the thought of another world view without becoming so defensive and closed-minded. So how could we achieve it? This will be the subject of future research, but the emotion of awe may offer one possibility. One study found that watching awe-inspiring videos about space and the universe led to humbler thinking, including a greater capacity to admit weaknesses.

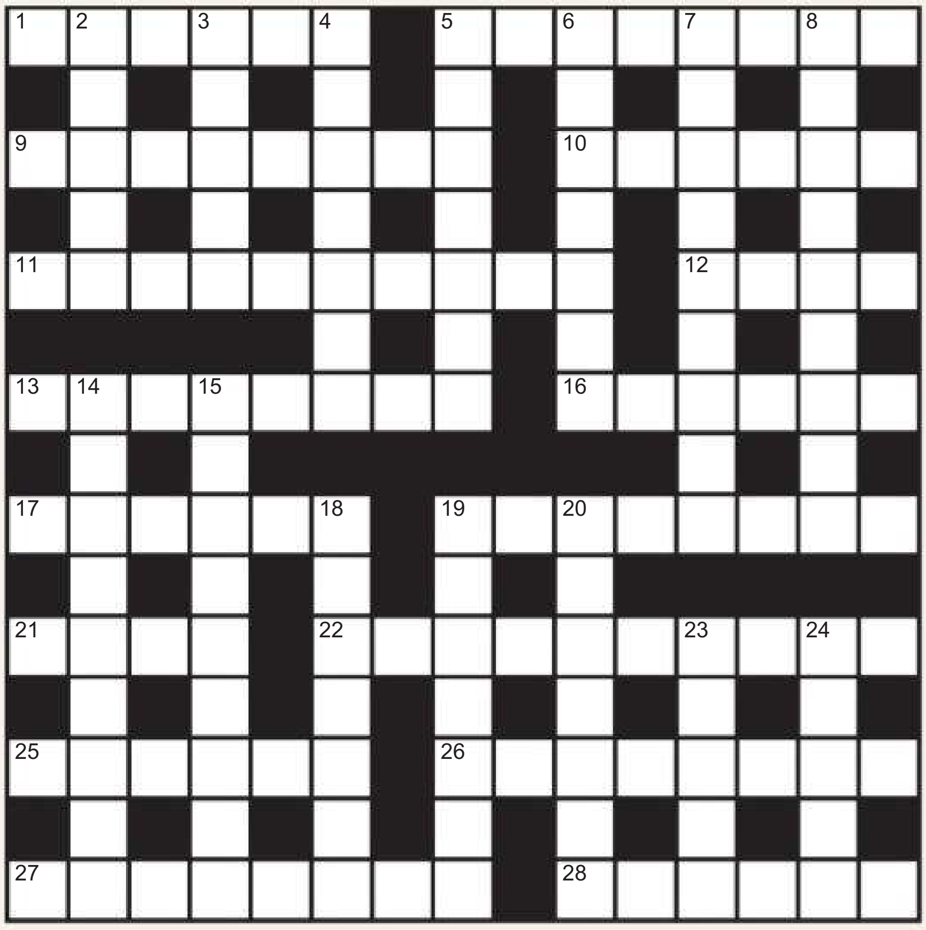
Perhaps we could all benefit from interrupting our doomscrolling with awe-inspiring content such as this image of the Pillars of Creation (above). At the very least, we can try to question our preconceptions before offering our views on social media – and be a little less ready to lash out when others disagree. ■

60-second psychology appears monthly

Next week
Stargazing at home

These articles are posted each week at newscientist.com/maker

Quick crossword #146 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 O (6)
5 Spine (8)
9 Leadwort (8)
10 Room to manoeuvre (6)
11 Bird of prey, native to Asia and East Africa (4,6)
12 1000 (prefix) (4)
13 City struck by the "Fat Man" bomb in August 1945 (8)
16 Concerning genetically identical organisms (6)
17 *Don't ___*, 2021 climate change satire (4,2)
19 Plant stalk (8)
21 Medicine vessel (4)
22 10^7 (3,7)
25 Edible root vegetable (6)
26 Branch of mathematics invented by Isaac Newton (or Gottfried Wilhelm Leibniz) (8)
27 Seats of perception (8)
28 Walter ___, chief designer of the V2 rocket (6)

DOWN

2 Transport tissue in vascular plants (5)
3 PlayStation user, possibly (5)
4 ___ Falls, major waterfall in North America (7)
5 Tubes connecting the trachea and lungs (7)
6 Concerning the large intestine (7)
7 Collapse; cessation of normal function (9)
8 98 per cent, say (6,3)
14 Epoch following the invention of nuclear weapons (6,3)
15 Organic, nitrogen-containing bases (9)
18 ___ plant, any of several carnivorous species that deploy pitfall traps (7)
19 Hypothetical cure-all (7)
20 Gottlieb ___, German inventor and industrialist (7)
23 Wingless parasitic insect (5)
24 Female reproductive structure, in plants (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #228
set by Bethan Ackerley

1 Fresnel and Fraunhofer are two types of what?

2 Which Earth year is commonly adopted as the beginning of the Martian calendar, as proposed by researchers in 2000?

3 Which French neurologist is mentioned in the novel *Dracula*?

4 In which city is the main Nobel prize ceremony held?

5 Jiahu in China is a site associated with which Neolithic culture?

Answers on page 47

Headscratcher
set by Mary Ellis
#248 Pizza parity

"You know how you ordered one medium pepperoni pizza and one medium broccoli pizza?" said the delivery man. "Well, unfortunately the order got a bit mixed up and I have one large pepperoni pizza and one small broccoli pizza."

"No big deal!" exclaimed Poppy. "There's two of us, so we'll each take half of both pizzas and we'll have the same amount!"

"Good plan," said Toby, "except for the part where I have to take any amount of your broccoli pizza – you know that I hate broccoli! Now, if I can just work out the ratio between a large and small pizza, then use the area of a circle to..."

Poppy smiled and grabbed a pizza cutter. Without slicing the small pizza at all, she made a single cut that allowed them to each take half of the total amount of pizza, while giving Toby only pepperoni.

How did she manage it?

Solution next week

Ready for take-off

Do winged animals like birds ever suffer comparable mishaps to those of human-made aircraft, such as aerodynamic stall, wing icing or hard landing?

Chris Woolf
St Neot, Cornwall, UK
From observation, controlled flight into terrain seems to be the most common failure. As with human-controlled aircraft, when vision becomes unexpectedly confused, birds fly into things, such as windows, with terrible regularity. Geese seem good at water landings, but I have watched them topple ignominiously when hitting a piece of weed or ice that didn't register in their flight plan.

As for stalling, birds seem to make a virtue of it rather than it being a mishap. I am impressed by seagulls intentionally stalling one wing in order to make a fast, over-the-shoulder attack, allowing them to roll steeply to grab the ice cream or pasty held in their victim's opposite hand. Two-wing powered flight returns shortly after, with the risk of minimum altitude, as well as beak load, to contend with.

> **"Seagulls intentionally stall in order to make a fast over-the-shoulder attack, rolling steeply to grab the pasty in their victim's hand"**

You can frequently watch birds such as jackdaws deterring predators – including buzzards – by climbing above them and stalling both wings to begin a plummeting drop onto the target. This is usually followed by another powered climb into a stall turn to attack again as quickly as possible.

John Ford
Amersham, Buckinghamshire, UK
I have watched murmurations of starlings, awestruck at their skill in formation flying. Then, one winter's evening off the pier in Eastbourne, UK, I discovered they aren't infallible. The lead bird took its flock perilously close to the sea and, either due to misjudgement or an unexpected gust of wind, disaster struck. A wing glanced the surface and in it tumbled, followed by hundreds of others.

In total disarray, they managed to extricate themselves and fly to the pier. Not to their roost below the pier, but to every available drying surface above. I feared that many of the bedraggled aviators wouldn't survive the night.

Andy Douse
Drumnadrochit, Highlands, UK
All birds have to stall when landing, not having the benefit of a long runway to manage a controlled landing. The key to doing that safely is slowing themselves down to a speed that is low enough for them to perch or safely touch down on the ground. And yes, bird wings can and do ice up, which can be a serious problem when they are flying at or near their maximum weight, for example during migration, when they are carrying high fat loads to fuel such long flights.

Hard landings are also a common occurrence, especially in young birds learning to fly. Birds landing on ice can experience a similarly uncontrolled hard landing, and it is well known that swans and other waterfowl may mistake hard surfaces for water. This is often due to refraction in the air above hot surfaces, such as roads, and causes an unexpected and probably very hard landing. We can presume this is why we see so many reports of swans on motorways, especially in summer.

TIM DE WAELE/GETTY IMAGES

Would a solo rider cycling at the same speed expend less energy than one leading a peloton?

This week's new questions

Easy rider **A cyclist saves energy by staying in the slipstream of the rider in front. But does the rider in front expend more energy than a solo rider travelling at the same speed?** ***Paul Fairfield**, Bebington, Merseyside, UK*

Full stop **If Earth stopped rotating, would this affect the force of gravity?** ***Lyn Williams**, Neath, Port Talbot, UK*

Mark Parker
Sway, Hampshire, UK
Some decades ago, while working in the Kalahari desert with a helicopter crew, I was living in a large caravan with a veranda. A black potter wasp, probably *Delta emarginatum*, built her mud nest inside an open cupboard in the caravan and began provisioning its cells with caterpillars. She captured this prey and paralysed them, then transported them to her nest, grasped in her legs below her body and held by her mandibles near the head end.

The third caterpillar she brought was several times her size and weight. The day was hot and still, at least 35°C (95°F), and inside the caravan, it was stiller and a few degrees hotter. She couldn't remain airborne in the lower-density, hot interior air and made a forced landing below the nest, which was on the rear wall of the cupboard, about 10 centimetres above a shelf. She was able to stay aloft just above the shelf due to the extra lift generated by being near to the surface, known in aviation circles as ground effect, but she couldn't generate enough lift to reach the nest.

After a few goes, she flew out of the caravan, still in ground effect, across the shelf and the floor, then circled to gain height in the cooler outside air, and returned to the caravan to try again, faster than previously, obviously hoping that her height and momentum would be sufficient to reach the nest. She was unsuccessful, but tried this a few times before giving up and abandoning the big caterpillar.

This potter wasp had evidently learned how to trade height for speed and how to make use of the ground effect. The helicopter crew found this to be a fascinating lesson in aerodynamics.

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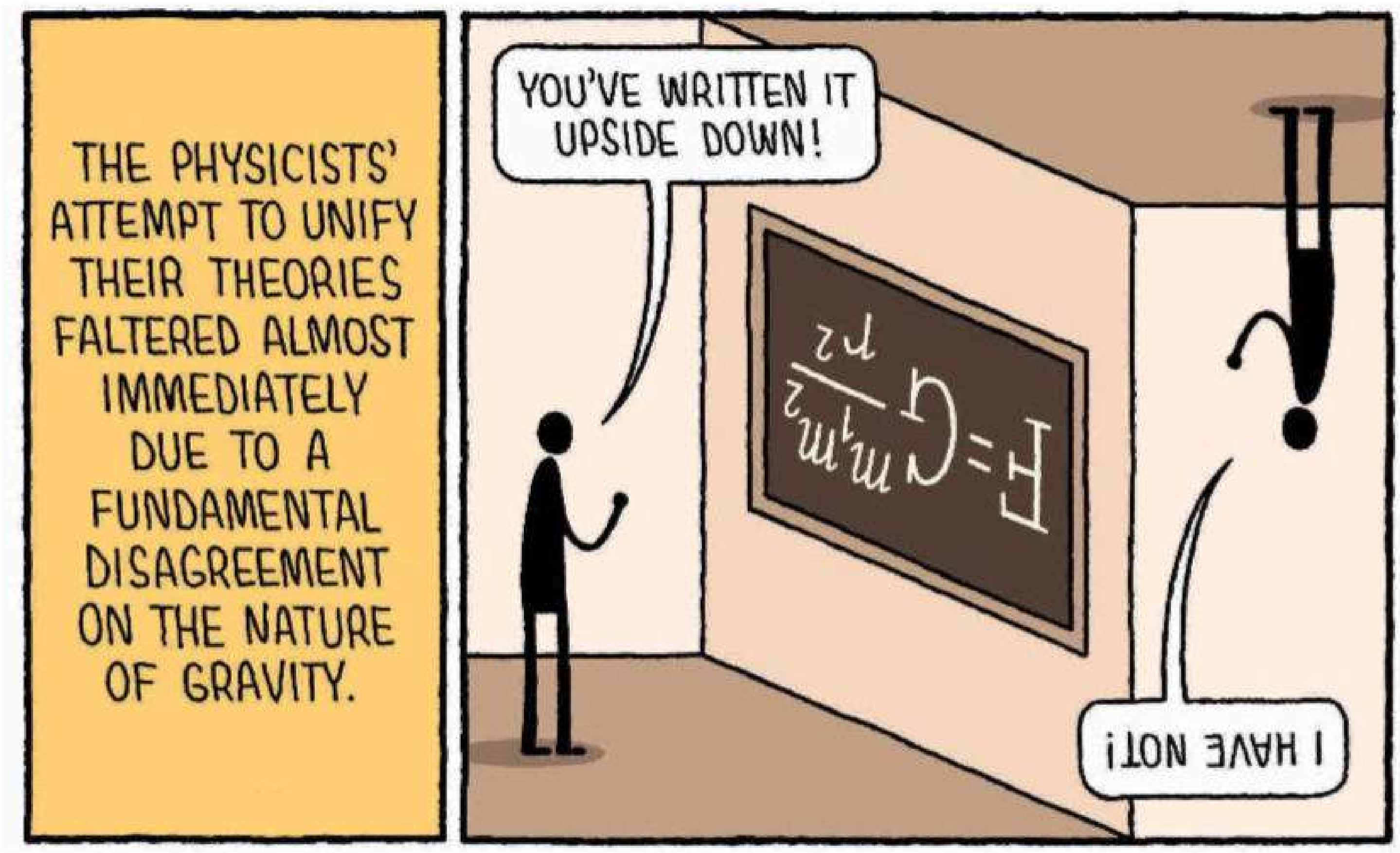
Tom Gauld
for New Scientist


THE PHYSICISTS' ATTEMPT TO UNIFY THEIR THEORIES FALTERED ALMOST IMMEDIATELY DUE TO A FUNDAMENTAL DISAGREEMENT ON THE NATURE OF GRAVITY.
YOU'VE WRITTEN IT UPSIDE DOWN!
F=Gm1m2/r2
I HAVE NOT!

Worn down

How long will it be until the pyramids in Egypt weather away completely?

Mark Thompson
Tewkesbury, Gloucestershire, UK
The Great Pyramid of Giza, built on the orders of Khufu (Cheops) in 2540 BC, is the numero uno of pyramids, with superior materials, engineering and design know-how to any built before. Ancient Greek tourists would travel thousands of miles to stare at its towering limestone steps.

Cleopatra lived closer in history to the construction of today's tallest building – the Burj Khalifa – than she did to that of the Great Pyramid. When the last mammoths died out, it was already several hundred years old.

It is less a building than an artificial mountain, made of nearly 6 million tonnes of solid rock. Five thousand years is no time whatsoever when you consider the limestone had been lying in the ground for 50 million years or so. So what will cause its destruction?

> **"When the last mammoths died out, the Great Pyramid of Giza, built in 2540 BC, was already several centuries old"**

A meteor strike? Let's hope not, as that wouldn't bode well for humanity.

An earthquake? There have been several over the time since it was built, but the only one that affected the pyramid took place on 8 August 1303, loosening many of the outer casing stones.

Weathering? The engineers shaped the stones to incredible tolerances to prevent the freeze-thaw effect on the rock. However, one estimate is that the erosion is about 0.1 centimetres per decade, which is approximately 1 metre every 10,000 years.

Global warming? It could raise the floodplain, or it could add to the intensity of the freeze-thaw erosion rate. But even so, it will take a long, long time (unless we humans really screw things up).

Another thing to note is that a stone pyramid is hard to beat for stability. There is almost no way for it to collapse, given a stable base, and it can't burn down.

Spinning out

What makes galaxies spin in a certain direction? And do they all spin in the same direction? (cont.)

Steve Powell
Hursley, Winchester, UK
One aspect of this question seems not to have been addressed. Spiral galaxies spin, we are told, and their direction of spin depends upon our perspective, of course. But do the outer points of the spirals precede or trail the rotation?

We instinctively feel that the arms should be "swept back" from, or trail behind, the rotation. But that, surely, is a result of our local experience of rotations driven centrally in a friction-providing medium, as for a Catherine wheel. What is the case in the heavens? ▮

Answers

Quick quiz #228
Answers

1 Diffraction
2 1955
3 Jean-Martin Charcot
4 Stockholm
5 The Peiligang culture

Cryptic crossword #122 *Answers*

ACROSS 1 Blister, **5** Get-go, **8** Neuralgia, **9** Mop, **10** O-ring, **12** Nodules, **13** Invisible hand, **15** Hangman, **17** Equip, **19** Leo, **20** Somnolent, **22** Rayon, **23** Needles

DOWN 1 Bingo, **2** ICU, **3** Tear gas, **4** Rag-and-bone man, **5** Gland, **6** Tamil Nadu, **7** Opposed, **11** Inventory, **13** Inhaler, **14** Eyesore, **16** Meson, **18** Putts, **21** Eel

#247 Bargain birthday badges
Solution

Grandad only needs to buy 12 badges to cover 21 birthdays.

He will need a badge for 1 as well as one for each of the prime numbers up to 21. That is 2, 3, 5, 7, 11, 13, 17 and 19. He will then need extra badges for composite (non-prime) numbers that have repeated prime factors. For example, 4 is 2 × 2, so he will need either an extra 2 or a 4. By choosing a 4, he won't need an 8. Continuing to build his badge collection in this way gives Grandad one possible final set: 1, 2, 3, 4, 5, 7, 9, 11, 13, 16, 17, 19.

Off-putting hair advice

Cutting remarks of a literal kind fill a study called "Off with her hair: Intrasexually competitive women advise other women to cut off more hair". The research potentially will inspire other kinds of cutting remarks.

A team of seven researchers, all women, at Charles Sturt University and Federation University, Australia, asked women to provide "advice to female clients in a hair salon as though they were the hairdresser, as to how much hair the client ought to have cut off". The results are displayed in the journal *Personality and Individual Differences*.

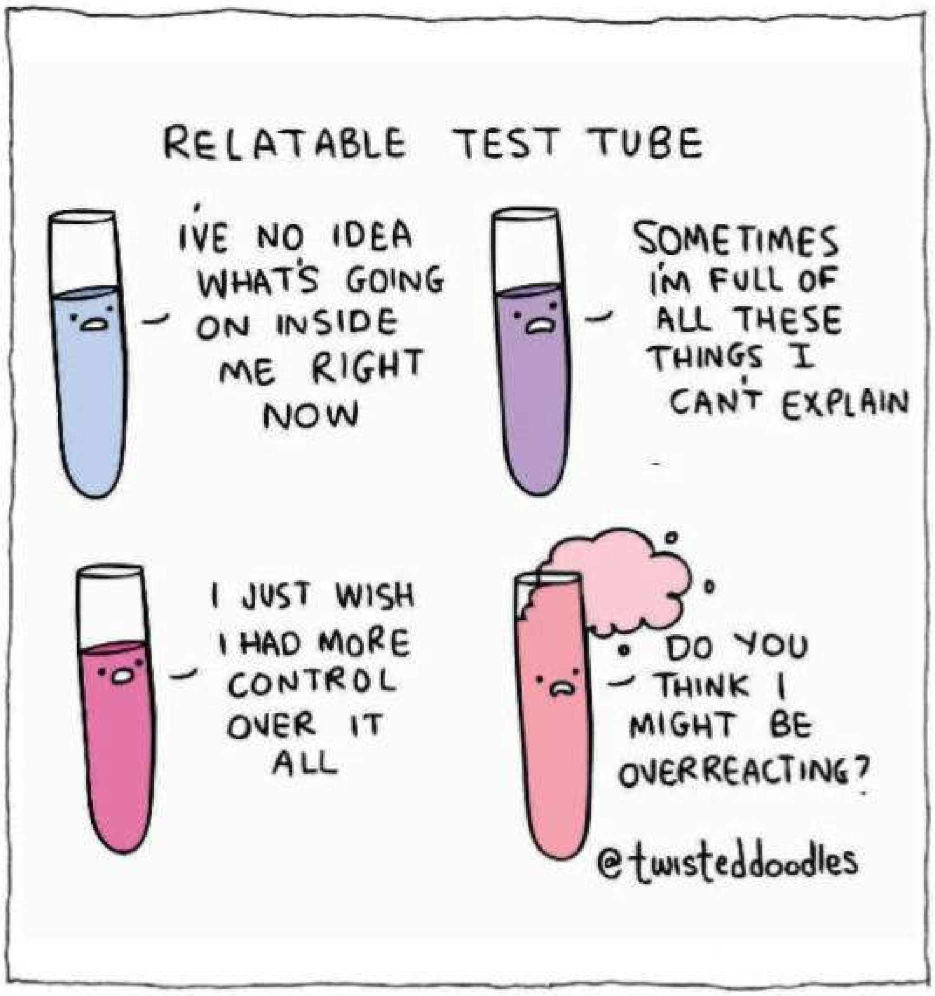
The paper begins by listing many common beliefs – all documented less or more well by earlier research – about long hair. Some people see lengthy locks as an indicator of "a woman's youth, health, and therefore fertility". When long hair is "experimentally added" to photos of women's faces, some men, says the paper, rate the hair-enhanced women as being more "youthful, healthy, sexy and feminine" and "more intelligent and dominant".

Those and related assumptions inspired the hypothesis examined by these researchers: that "recommending that a client cut off more of her hair, especially when that hair is healthy, could diminish the client's physical attractiveness, and hobble her capacity to manipulate signals of sexual intent."

Here are the stated discoveries: "participants' intrasexual competitiveness positively predicted how much hair they recommended clients have cut off, especially when the hair was in good condition and the clients reported wanting as little as possible cut off – circumstances wherein cutting off too much hair is most likely to indicate sabotage".

That passage, together with the study's conclusion, could perhaps be published alone as a miniature literary novel of the cause célèbre variety. The conclusion says: "the primary targets of competition in our study were women of average attractiveness, those perceived by participants to be as attractive as themselves. Least targeted were highly attractive women. These are interesting observations because the primary costs of female indirect aggression are the risk of retaliation and reputational harm".

Twisteddoodles *for New Scientist*


RELATABLE TEST TUBE
I'VE NO IDEA WHAT'S GOING ON INSIDE ME RIGHT NOW
SOMETIMES I'M FULL OF ALL THESE THINGS I CAN'T EXPLAIN
I JUST WISH I HAD MORE CONTROL OVER IT ALL
DO YOU THINK I MIGHT BE OVERREACTING?
@twisteddoodles

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Consideration of items sent in the post will be delayed

Zeppelin communiqué

Feedback's mention (14 October) of the paper "Communication breakdown – It's always the same (but it's avoidable)" was old music to the ears of Richard Ives, age 72.

He says: "You obviously missed the Led Zeppelin reference in the title of the paper, which was, to us Led Zeppelin fans, a nod to their song *Communication Breakdown* on their eponymous 1969 album, *Led Zeppelin*: 'Communication breakdown, it's always the same / Havin' a nervous breakdown, a-drive me insane, yeah.'

"I only know this because I am really old and, as I didn't do drugs then, I remember the Sixties. The tendency of authors to make such obscure references is to be regretted as another form of discrimination against young researchers."

A weighty matter

In our 28 October issue, Feedback warned of problems arising from attempts to solve other problems – a warning that now has an echo in the food and medical industries.

The new hoo-ha emanates from the weight-loss drug Ozempic. Ozempic was designed to solve the entwined problems of, first, people wanting to slim their torsos and, second, drug-makers wanting to fatten their profits.

News reports tell of worries by executives at Walmart and other companies that sell or manufacture vast quantities of snack-foody treats – worries about the effect Ozempic might have on the size of their markets and profits. Other reports bring concerns by financial industry strategists that "obesity medicine could dampen demand for food and reshape the 'food ecosystem'".

Feedback fears that these fears themselves might redirect substantial amounts of biomedical research funding: away from the tortoise-ploddy pursuit of better human health, and towards the hippity-hop flight down lightless holes rumoured to contain buried treasure.

The problems raised by Ozempic are already raising other problems. Doctors Clinton D. Humphrey and Anna C. Lawrence published an "alert" urging their peers to face up to the "Implications of Ozempic and other semaglutide medications for facial plastic surgeons".

Know thyself

Anything is possible, some of us like to think. Mario Brčić and Roman Yampolskiy say they think otherwise. They present evidence of this in a jargon-packed 24-pager called "Impossibility results in AI: A survey". Brčić, at the University of Zagreb, Croatia, and Yampolskiy, at the University of Louisville, Kentucky, categorise a bunch of mathematical theorems about tasks that – if those theorems are correct – aren't possible to accomplish using their own intelligence or (in their words) "artificial intelligence, especially the super-intelligent one".

The paper discusses, among much else, what it says are new results about the "Unfairness of Explainability". That discussion includes a statement that, Feedback thinks, could enliven many a conversation: "Explaining yourself truthfully and correctly would imply self-comprehension, which is a problematic notion itself". ■

Marc Abrahams

EARLY BIRD
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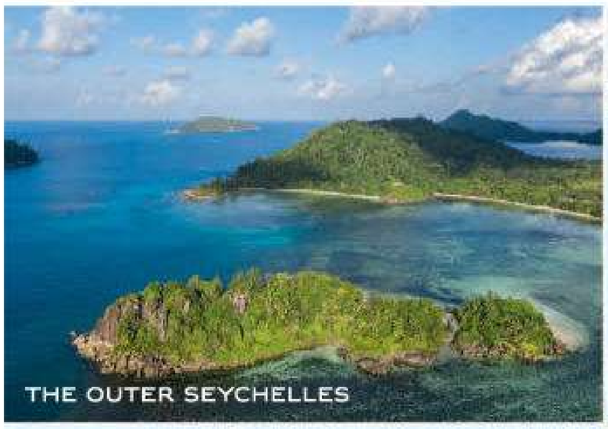

THE OUTER SEYCHELLES

AZORES ARCHIPELAGO, PORTUGAL

FLORIDA GULF COASTLINE, UNITED STATES

SYLVIA EARLE EXPLORES
COCOS ISLAND, COSTA RICA

THERE ARE OVER 130
HOPE SPOTS GLOBALLY

SYLVIA EARLE WITH VOLUNTEERS,
THE OUTER SEYCHELLES

GREAT BARRIER REEF, AUSTRALIA

MOBULA RAYS, AZORES
ARCHIPELAGO, PORTUGAL

SEA LION,
GALAPAGOS,
ECUADOR

ON OUR WATCH

Hope can now be spotted across all our planet's seas and oceans. Sites are made into aquatic havens by local communities, to safeguard the richness and diversity of the ecosystems they depend on. Sylvia Earle's invaluable experience as an explorer and marine biologist continues to help further their goal, through her organisation, Mission Blue. Together, they have created over 130 Hope Spots and counting. Carrying a message of hope for generations to come. It is that vision, that dedication to a perpetual planet, which we are proud to stand by. **For as long as it is needed.**

#Perpetual

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